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CVX DAMAGE CONTROL INFORMATION TECHNOLOGY EVOLUTIONARY MODEL

by

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CVX DAMAGE CONTROL INFORMATION TECHNOLOGY EVOLUTIONARY MODEL

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requirements for the degree of

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ABSTRACT

Tightening of the U.S. defense budget has been closing in around the twelve aircraft carrier navy throughout the 1990's. In spite of this budget decline, the quantity and quality of our most expensive weapons, the aircraft carriers, have remained stable over the same period. These six thousand man ships, however, could soon become unwanted remains of the days of a 600-ship navy when recruiting was easier and manpower was less expensive. Damage control operations aboard the carrier require the greatest quantity of manpower of any single operational requirement. The next generation of carriers promises to be just as large and more diverse in mission than the current design. Without an infusion of sound technological advancements, the quantity of manpower required to protect these new carriers threatens to reduce the twelve-carrier navy to a more affordable number. The goal of this thesis is to establish a "technology roadmap" by which CVX can avoid where possible and negotiate where necessary, the changes in state of the art damage control technology. A deliberate and technologically sound process for improving the damage control capabilities aboard future and existing aircraft carriers is possible. A strong investment in information technology planning will play a major part in optimizing capabilities and manpower requirements of CVX. The reward will be improved robustness, efficiency and quality of life, keeping the next generation of aircraft carriers a truly labeled "high value unit".

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INTRODUCTION

> "If you don't know where you are, a map won't help." —Watts Humphrey

A. PROBLEM

The trend of reduced U.S. defense budgeting that began soon after the end of the cold war has continued for ten years unabated. Over the period, the size of the Navy in manpower and ships has declined nearly 40 percent. (Figure 1) It is also true that during these same years, the number Aircraft Carriers in the fleet has remained steady at twelve. This magic number of carriers was arrived at in the 1993 Defense Bottom Up Review (BUR)[1] as the minimum required to provide a full time coverage in one of three regions. There are currently no plans to allow this minimum to decrease in the long-term budget.[2]

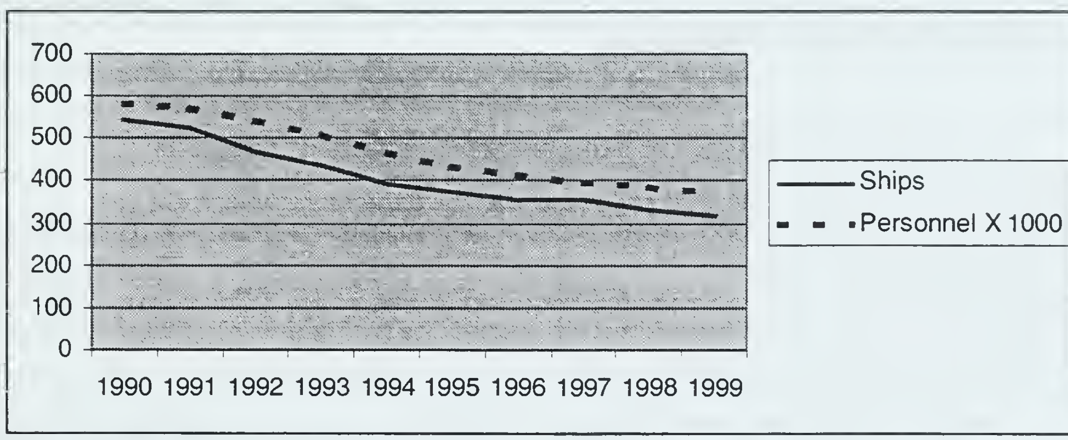

Figure 1 Dramatic decline in ships and personnel is not reflected in steady 12 carriers

The rising cost of building and manning ships in the 1990's has forced the Navy to seek new and innovative ways to reduce the number of man-hours required to do both tasks. Several initiatives have received wide audience with both military leaders and congress regarding ways to achieve these manpower savings without continuing to reduce the size of the fleet into the 21st century.

The Navy is now dealing with tight budget pressure by closely studying and implementing manpower reductions on operating ships under the "Smart Ship program". By replacing all but a few personnel on the bridge and in central control stations with automated indicators and state of the art computers, Smart Ship prototype, USS YORKTOWN (CG 48) demonstrated the ability to operate for sustained periods with a 15 percent reduction in the normal crew complement.[3] Since smart ship trials, three other ships have been outfitted with smart ship technology initiatives. More are expected and eventually the standard will be applied fleet wide. This reshaping of the Cruiser Destroyer (CRUDES) fleet will eventually impact aircraft carriers as well since the training base for the 12 active carriers is out in the 120 combatants that are dispersed to the Carrier Battle Groups.

Considering the shift in basic skills required to operate future ships of the CRUDES fleet, it will become imperative that the next class of carriers prepare to accept reduced levels of manning which will come with this automation. Navy planners must also ensure that collateral responsibilities such as damage control positions involving most of the crew keep pace with the reductions in overall ship's force to ensure operational effectiveness is maintained.

> "Even if you're on the right track, you'll get run over if you just sit there."
>
> —Arthur Godfrey

Implicit in the manpower reductions that are now coming to the fleet is a need to determine what tasks in the damage control arena can be safely and effectively automated. It is this facet of CVX which motivates this thesis.

> "If you don't know where you are going, any road will do."
>
> —Chinese proverb

1. The Technology Problem

Much of the technology we now employ onboard ships in the United States Navy is based on lessons learned since the advent of ironclad ships over a hundred years ago. Virtually all of the damage control equipment on our oldest active aircraft carriers is the original technology each of those ships was built with close to 40 years ago. Although some innovation has taken place to improve the safety and reliability of our damage control equipment, almost nothing has been done to make damage control a less manpower intensive operation onboard aircraft carriers.

An exceptionally high level of reliability is the basis for our continued use of most of the old equipment and techniques in use today. Damage control events in history remind us that when disaster strikes onboard ships at sea, the crew has nowhere to run. Methods for controlling damage onboard ships must be highly reliable, repeatable and adaptive to all contingencies. Sound powered phones that are currently the principal means of D/C communication never run out of power, the ubiquitous grease pencil can jot down information almost anywhere. However, it is reasonable to conclude with continuous research that an Aircraft Carrier designed today or in the future could meet the level of reliability existent in these current standards.

2. "Reliable" Technologies leave much to be improved upon

Current Damage Control Repair Locker organizations require an elaborate hierarchy of verbal communications and redundancy to pass even the simplest forms of direction through the fire party. This system often breaks down under the weight of its own redundancy or the simple narrow channel through which the communications of the repair locker travel.

Exceptionally detailed casualty rehearsals and leadership in the repair locker within this context is often the only means by which successful control of the damage control efforts can be accomplished. Even in the Navy's most shining examples of successful damage control can be found routine and fundamental breakdowns in the decision making, communications and cohesiveness[4,5]. This often resulted in prolonged efforts, additional risk to the ship, and less than optimal resolution of the conflagration.

This thesis proposes that the technology of CVX Damage Control systems integrate the "best of breed" technologies of the information age with 75 years of carrier

survival experience in order to meet the performance expectations and economic challenges of the 21st century.

3. D/C team too large

In pursuing high reliability we have learned that efficiency is an expendable aspect of damage control. As required by current fleet fire doctrine, when the potential for damage rises, large portions of the crew are called away to repair lockers to be ready to rapidly respond should the damage spread to their assigned area of the ship. On aircraft carriers, this portion can amount to nearly a third of the crew.[6] More urgent battle scenarios compound the requirements for this large manpower force by extracting mission specialists from other areas of the ship. These situations strain the ability of the remaining crew to accomplish the ship's mission for extended periods of time. A careful balance of priorities must be controlled by the already overwhelmed chain of command to keep the right number of people in damage control and combat roles.

4. Large team needed for capricious practices

Examples of these manpower intensive activities include dedicated phone talkers using "repeat back", a procedure to pass messages, not just a simple acknowledgement of receipt of the message. Another is the use of dedicated messengers to relay messages between the control centers. A third example of this redundancy is the manual plotting of damage throughout the ship within each repair locker to ensure that everyone has the big picture. These tasks alone on today's aircraft carrier's occupy nearly one hundred personnel at a time.[7] To train and evaluate the damage control team, a mirror organization of experts, the Damage Control Training Team (DCTT) monitors and trains the damage control organization.

5. Leads to larger support staff

All of this redundancy amounts to a growth in support personnel as well. Food, living conditions and pay must be provided to these workers at the expense of still more supply/support personnel. The upward spiral in personnel requirements has placed us at a decision point with respect to the next generation of aircraft carriers. CVX must take advantage of the productivity afforded by the information age. Without this change, the

cost of our military will continue to spiral upwards and eventually collapse at the insistence of taxpayers.

B. BACKGROUND

1. Does the need for Aircraft Carriers continue in the 21st century?

Aircraft Carriers have been around since the USS LANGLEY (CV 1) was commissioned in March 1922. Power projection in the air and on the sea has been a hallmark of the U.S. Navy's success for the last seventy-five years. As the presence of U.S. forces on overseas bases was drawn down though the 1980's and 90's the need for aircraft carriers to fill the strategic gap has grown substantially. Carriers are the first option to achieving a self-sustaining and immediate military presence where US national interests are threatened. It is stated that without the US ability to project military power, rogue nations of the world would go unchecked as they take advantage of their weaker neighbors. This would inevitably result in the US involvement in more regional skirmishes than ever beginning long after chances for a peaceful solution had vanished.

In the 21st century, aircraft carriers will continue to protect national interests by projecting power. The need to respond anywhere, anytime with potent force is the kind of credible deterrence that ensures free commerce on the open seas and the security of US trading partners and allies. The actions of the US government in shaping the Navy during the 1990s would appear to support this premise. During the extensive defense draw down of the early 1990's the size of the fleet was reduced from 558 ships in 1989 to 314 ships in 1999. This is a greater than 40 percent reduction. During the same period, the number of aircraft carriers has remained at a rock steady twelve. This amounts to a relative increase in the national commitment to aircraft carrier programs.

2. Why must U.S. carriers be so big?

Aircraft Carriers by their very nature are dangerous environments for man or machine. The constraints of limited storage space, demanding mission requirements and exposure to enemy targeting make these ships a complex environment full of tradeoffs pitting man against mission. Damage Control onboard is a vital part of ensuring that the

crew has the necessary tools to arrest, minimize and restore damage which may impact the ship's mission. It is a science as old as ships. Damage control on naval vessels is also important to the survival of the fleet. The complementary capabilities of different ship types in the battle group shield the rest of the group from various threats. Aircraft Carriers, because of their size and complexity are the most threatening and most threatened of the ship types. They are considered High Value Units (HVU's) due to their unique ability to project an umbrella of air control over the rest of the fleet. Damage control on aircraft carriers is as complex or more than that of other ship types for this reason. Several other nations have constructed much smaller aircraft carriers to defend their own national interests, generally plying the oceans adjoining their own coasts. The United States is the largest trading partner in the world by far and as such, has assumed the role of a global defender of the rights to freedom of navigation. The great size of these vessels is a function of their need to sustain combat action in a prolonged conflict and to retain stability in high "blue water" sea states for safe launch and recovery of aircraft. The size difference of these vessels from other U.S. Navy ships however, remains an important cost factor.[8]

3. Early Obsolescence

Rapid development and obsolescence of software and hardware technology standards in the commercial world provide a constant flow of capital to each new design that is put forth on the market. Examples of standards which were considered viable only a few years ago are hurtling toward the scrap heap as we develop new systems with greater speed, bandwidth, and more features than ever before. Consider the 5 1/2-inch floppy disk which just fifteen years ago was the standard medium used to store programs and data. There are few machines operating in the world today which could even read these disks regardless of the value of information stored on them. Consider the DVD disks of today and the likelihood that by the time CVX is operational, these disks may well be as obsolete as an 8-track tape. For the proposed 50-year life of one of these ships, we can safely assume that hardware and software standards will go through several evolutions. These evolutions will be incremental as the improved capabilities of one system device make it possible to advance the technology in several others. The clearest example of this is in the microchip that has developed a lifecycle of its own by doubling in speed every 18 months, a phenomenon known as "Moore's Law".[9]

4. Technology GAP?

The choice of CVX as a platform for improved damage control technology is based on the expectation of greatest cost benefit. Surface fleet ship types are currently prototyping many of the same concepts which we will explore. A damage control technology gap is now evident due to hesitation to attempt a "clean sheet" approach to new technology investments onboard Naval Air (NAVAIR) ships as compared to the latest Cruiser Destroyer (CRUDES) Fleet. In order to prepare aircraft carriers for the coming wave of efficiencies of the information age, we must be prepared to "absorb and extend" the technologies that are now occurring in the surface navy.

C. PURPOSE/OBJECTIVE

The purpose of this study is to analyze the principal factors that will determine what technologies are implemented in CVX. Secondly, those principal factors will be applied to determine which technologies promise the most reliable stable and useful products to be sought in the development of CVX. The primary question the study will address is:

What factors will dictate the design of the CVX damage control system? More specifically:

- Will automation reduce required ships manning? If so, what uses of manpower can be automated?
- What level of reliability would be acceptable and would exceed current systems?
- What can be done to minimize the risk of delayed, under performing, or faulty software?
- What system architecture will meet damage control tasking and provide commonality with the ship wide systems?
- What methods should be used to evaluate each technology for utility?
- What can be discovered through prototypical testing such as smart ship?
- Can decision aids benefit damage control?

D. SCOPE AND LIMITATIONS

This study will focus on the damage control technology used in CVX, the next generation of Aircraft Carriers. It will cover the changes in technology, which have occurred since the last (USS NIMITZ) aircraft carrier design was created in 1968. The thesis provides recommendations on building a damage control technology roadmap by which the diverse but interrelated technologies can be synthesized into a cohesive damage control system that reduces direct acquisition costs and manpower while increasing safety and reliability. These technologies include hardware, software, doctrinal, and architectural implementations.

E. ORGANIZATION

This thesis has 5 chapters. Chapter I defines the problem and provides background information. Chapter II is a technology overview to outline the various state of the art implementations and to define the context in which they will effect CVX. This chapter outlines the strengths and weaknesses of each new technology in preparation for an emphasis on only the most promising. Chapter III discusses the carrier acquisition process and the considerations that must be addressed en route to a final design. Chapter IV describes the technology selection model and defines the criteria and normalization process for technology selection. Chapter V systematically itemizes the technology implementation issues that remain to be resolved with each technology area. Chapter VI is the final analysis and Chapter VII provides conclusions and recommendations resulting from the findings of the final analysis.

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[1] Government Accounting Office, GAO/NSIAD-998-1, *NAVY AIRCRAFT CARRIERS: Cost Effectiveness of Conventionally and Nuclear Powered Aircraft Carriers*, By Richard Davis, p. 21, 27 Aug 1998

[2] Office Of the Secretary of Defense, "U.S. Military Personnel In Foreign Affairs." [http://www.dtic.mil/execsec/adr95/appendix_c.html]. March 1999

[3] Commander U.S. Naval Surface Force Atlantic Fleet, Ser N6/1687, *Smart Ship Project Assessment*, Giffin, H.C. , 19 Sept 97, pp. 5,

[4] "Aftermath of a Tragedy: USS Stark missile incident", *FATHOM*, Spring 1988, p. 2-5

[5] "Saving the Samuel B. Roberts, : mining incident" *FATHOM*, Fall 1988, p. 2-7.

[6] Telephone Conversation between LCDR K. Yang, DCA, CVN-74 and the author, 26 Feb 1999.

[7] Ship's Battle Bill, USS John C. Stennis (CVN 74), Dec 1996

[8] Naval Research Advisory Committee, NRAC-97-01, *CVX Flexibility*, by W. Weldon and others, p. 32, Oct 97

[9] Lewis, T.G., *The Friction Free Economy*, p. 6, 1997, Harper Business

II. THE CONFIGURATION PROCESS

A. CONFIGURATION ASPECTS

There are many aspects of the technology roadmap that must be investigated, considered and decided upon in order to arrive at an optimal solution for the design of CVX. Many off these decisions are interlaced with others such that a change in one decision may warrant reconsideration of several others. This chaining effect can cause us to get caught up in the minutia of what must be determined and lead to "Analysis Paralysis". Keeping a structured approach to the question of what must be determined and an eye on the goals of the CVX stakeholders will lead us to accomplish sound and progressive decisions and allow us to document our reasoning for future recall so that we may reapply it should a decision need reconsideration. By building our design structure like a pyramid from the bottom up, we can lay a foundation of fundamental choices which permit the widest amount of discretion in the later, implementation of the design. (Figure 2)

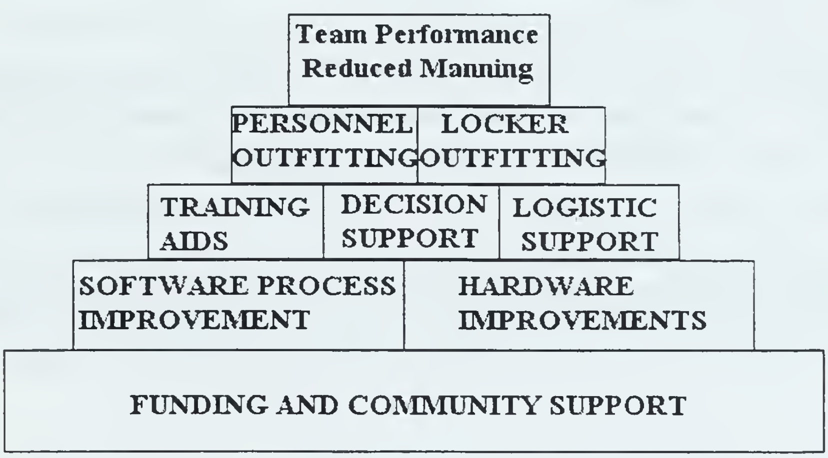

Figure 2. Software Process Improvement must be in place to expect reliable and timely processes to deliver highly complex human interface software which is critical to life and safety.

B. SIX CRITERIA OF THIS STUDY

CVX will be developed with the concerns of many stakeholders in the balance. Criteria for the selection of Damage Control Technology can be synthesized from the goals of each of the three key stakeholders. The Office of the Secretary of Defense (OSD), Naval Sea Systems Command (NAVSEA), and the users of the technology, made up of members of the existing fleet have each identified their goals for CVX with some crossover between each of them. We will combine these goals to produce an amalgam of 6 basic criteria that will be scaled for measuring each technology. Some technologies do not engage all 6 criteria that will be noted in the upcoming analysis. In order to apply rounded weighting of which technologies will best meet the requirements of various stakeholders in the process, the following table of attributes was constructed with the goals of those stakeholders in mind.

In accord with its CVX "Mission Needs Statement", ***"Manpower"*** reduction is a primary goal of NAVSEA in the new carrier design. Also identified in this defining document is the need to develop stable and ***"Mature"*** damage control technology to ensure continuity of the training and readiness of the fleet is very important as well as the ability to ***"Back fit"*** CVX technology (NAVSEA) [1,2]. DOD's information technology goals for 1999 as specified in the Secretary's "Annual Report to the President and Congress" encompass all three of the above goals and additionally state that ***"Integration"*** of new technologies is a primary concern. The consideration of the users of this technology is also a strong factor in the selection of which areas warrant improvement. This is captured through a fleet survey on technology ***"Preferences"*** and weighting of which characteristics of the new technology bear the greatest ***"Significance"*** in technology selection. (Appendix A) All criteria are summarized in Table 1. Additionally, Figure 3 is included to show the Kiviat graph[3] for a perfect solution. From this data, several technologies and their ability to maximize the six measures will be determined in Chapter IV and used to justify acceptance of those technologies.

	A. **Manpower Reductions** (NAVSEA/OSD)	B. **Most Needed Preference** (Users view)	C. **Information Technology Integration** (NAVSEA/OSD)	D. **Chosen Characteristic : Reliability** (Users view)	E. **Back Fit to previous CV/N fleet capable** (NAVSEA/OSD)	F. **Standards/ technology maturity** (NAVSEA)
5 Best	Cuts manpower by 30 % or more for this task	Strongly Desire	Fully modular / Enables other technology	Improves reliability of other components	Included at no cost or delay	Solid stable technology
4 Better	Definite but less than 30 % reductions	Desire	Common hardware/inter-faces with ship	Adds features and reliability	Included at per ship cost after prototypes are proven	New but proven performance
3 Good	Some man power reductions expected	will tolerate	Networks with various ship systems	Adds Features or reliability	Not included but available	Available/ Unproven
2 Fair	Potential for manpower reductions	Not committed	Uses data from other systems	As reliable as original solution	Possible but cost prohibitive	Prototype Only
1 Poor	No manpower reduction	Rejected	Stovepipe method	Task not degraded but more unreliable	Not possible but not essential either	Conceptual only
0 Bad	Requires <u>more</u> manpower	Strongly Rejected	Competes with or excludes integrated technology	Task Degraded by unreliability	Needed not supported or possible	History of failed prototypes

Table 1. Indicates scalar characteristics (columns) of each criterion to be evaluated. Upper values representing best performance of the goal listed at the head of each column in bold.

C. CIDE VS STOVEPIPE NETWORKS

The prospect of building a Carrier Integrated Digital Environment (CIDE) with full integration of various audio, video and data streams moving seamlessly thorough the same fiber trunks is the focus of network builders of today. Considering the stovepipe systems of the current aircraft carriers in which fiber optic cabling lies alongside copper in countless discrete cable runs from one end of the ship to the other there is tremendous cable weight and dedicated capacity to be removed or integrated into the CIDE for flexibility. An inspection of cabled systems and their destinations quickly reveals that public address systems, telephone systems, video cabling, ship's LAN, sensor and alarm systems and many others run side by side connecting each space with the next. The design of aircraft carriers places much of the electronics and work spaces above the waterline. With the cable plant serving users in these topside areas of the ship, it's weight must be ballasted in the hull to ensure the ship retains stability underway. Blown fiber optic cabling and FDDI redundant loop network cabling will reduce the weight, provide exceptional redundancy and encourage users to integrate their product to use the network

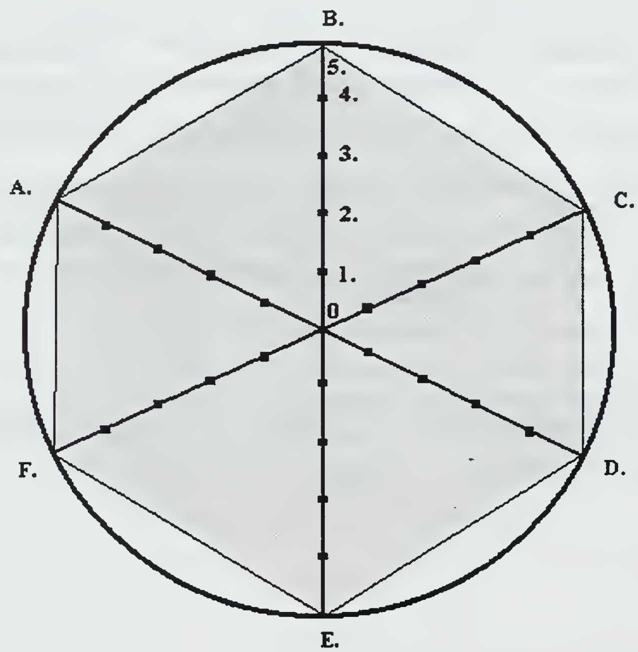

Figure 3 . Example Kiviat graph. Full extension of all radials indicates perfect compliance with all project goals.

vice building another one purpose cable system.

The current Definity 75 telephone system installed throughout the CV/CVN fleet actually operates a packet ready ISDN network capable of expansion to accommodate much of the data now in the dedicated LAN according to system designers. This modern networking capability however, has not been developed beyond its initial installed capability as a simple telephone system.

D. SMART SHIP

Smart Ship is an experimental attempt to reduce crew size while increasing effectiveness of the manpower onboard USS YORKTOWN. In the two years since implementing changes from manpower to machine power, it became clear that some of the changes were not yet ready for use in the Navy. The Navy is also not completely ready to adjust for and accept some of the changes proven effective on USS YORKTOWN. Taking advantage of shipboard automation and a crew heartened to make a significant change in the way the Navy does business, Captain Rushton and his men got underway with a twelve percent reduction in crew size while completing all of the ships' assigned operational examinations and mission assignments.[4] Subsequently, with rotation of the Smart Ship crew including Captain Rushton, YORKTOWN no longer has a mandate to "prove" the viability of the concept. Smart Ship seems destined to recede into pre-Smart Ship manning levels and has regained some of the cumbersome administrative practices of old.[5] Additionally, the Secretary Of the Navy has stated that excess personnel saved from these economies can be reassigned within the ship to reduce the workload on their shipmates. The rapid development of software interfaces between new onboard computers and the existing engine controls contributed to software gaps that resulted in an embarrassing and dangerous loss of propulsion on more than one occasion. Skeptics of the Smart Ship concept have quickly "gone public" to warn the rest of the navy against these dangerous excursions into the technological unknown[6]. Without preparing subsequent crews including the new Commanding Officer and inspection teams to embrace the Smart Ship concept, much of the momentum for change has receded. Captains and crewmembers have reverted to practices and routines from their previous shipboard tours to guide them in their new roles on Smart Ship. Even if a new captain and crew on YORKTOWN were totally steeped in Smart Ship philosophy prior to coming aboard, the pressure from outside the ship to restore conventional operational practices

and to accept conventional manning levels seems destined to restrain Smart Ships for years to come.

These same forces can be expected to act on the first Aircraft Carrier to attempt substantial manning reductions if nothing is learned from Smart Ship.

Beyond the technologies introduced on YORKTOWN many new innovations have appeared since the design of the last Aircraft Carrier USS NIMITZ. When NIMITZ was designed in 1968,[7] the Navy was experiencing several major Damage Control Catastrophes leading to changes in procedures and equipment fleet-wide. Tragic fires onboard USS ORISKANY, USS FORRESTAL and USS ENTERPRISE, each with a great loss of life in 1966, 1967 and 1969 drove the Navy to make smarter use of the technology of the day.[8] Many of the lessons learned then are in use today. However, technology breakthroughs we are now experiencing invite us to continue to improve the effectiveness of our damage control systems while reducing the manpower and resources expended on them. The following pages explain a few of the technologies, their benefits and shortcomings that can be expected to contribute to these changes.

1. Can Smart Ship provide answers?

In November 1995, a Naval Research Advisory Committee (NRAC) found that the key to manpower reductions on naval ships was a change in traditions and culture combined with employment of new technologies. The Chief of Naval Operations (CNO), acting on the report, directed the Naval Sea Systems Command to identify and evaluate Commercial Off the Shelf innovations which would minimize the risks of automating shipboard functions allowing manpower reductions to be implemented. One year later, most of the innovations were installed on USS YORKTOWN (CG 48) at a cost of approximately 32 million dollars. The ship put to sea for five months to prove that nearly fifteen percent of the crew could safely be left behind without degrading the ship's capabilities.[9]

2. What does this mean for CVX?

Given the much greater timeline for development and the scope and context of new construction the process of designing and constructing the next aircraft carrier will avoid the compressed path taken by Smart Ship. However, there is much to be learned from the Smart Ship process that can be applied to CVX. From its inception in 1994, the

Smart Ship project was understood to be a bold endeavor that was not without risk. The overall expense of the innovations provided to USS YORKTOWN and its follow on entourage of Smart Ships is but a tiny fraction of the cost involved with CVX development. If we were to construct another ship with all of the innovations added to USS YORKTOWN from the keel up there would clearly be a great cost savings over the original design. This is due to several considerations:

- Incorporation of Commercial off the Shelf (COTS) products rather than developing dedicated legacy systems from scratch eliminated much of the overall cost.
- Shortened development time required to use COTS yields more savings in trial and error refinement time of operational programs over the life of the ship.
- Modularity and competitive sourcing of upgrade components makes improvement flexible and more affordable beginning the day the first system was complete.
- Use of frequent incremental software upgrades rather than monolithic hardware upgrades leads to greater operational capacity and decreased crew atrophy.

The development of innovative systems used in Smart Ship were selected in relatively short order (6 months)[10] by a consortium of engineering organizations dedicated to the task. The inclusion of standardized Software Process Improvement (SPI) technology, while acclaimed and becoming more widespread, did not play a significant role in the process of building the operating systems. Consider then that the success of Smart Ship could perhaps have been still more enhanced simply by insisting on contractors that have set a foundation for minimizing risk and uncertainty. Contractors could also have been better prepared to say unequivocally that the inclusion of certain functions to the Smart Ship could be done both on time and at cost very early in the process. Some operational testing was done on the COTS components of Smart Ship to ensure the concepts were feasible in practice as in theory. We should establish however, collect a body of knowledge which will allow us to observe and rate the reliability of each smart ship type of initiative prior to putting it into use in the fleet. With an analysis template for software projects, we will be able to learn from the mistakes and correct them before they repeat. If we consider this information in our expectations for future

ship software design, our ability to control costs and reduce waste may be much more dramatic in the process of obtaining CVX.

E. SOFTWARE PROCESS IMPROVEMENT (SPI) AND THE CAPABILITY MATURITY MODEL (CMM)

Microprocessors and most other hardware devices used now for computing in the "Internet Age" are exceptionally reliable. We rarely hear about hard drives failing, chips burning out or physical damage to equipment. What *has* remained part of the 1990's computing experience are software failures. As the century comes to an end, we have managed to nearly perfect the manufacturing processes that create millions of copies of whatever hardware device we want with extreme precision. This iterative process by which industry's precision and sophistication with materials has risen to unforeseen levels, eliminates defects and manipulates minute particles to the limits of the laws of physics. Examples of this are hard drives and microcircuits that are now several magnitudes greater capacity over their immediate predecessors while losing nothing in reliability. Conversely, during these same years of development, experts have dealt with the technology of binary software and have yet to successfully create an operating system that has the ability to prevent itself from malfunctioning on a regular basis.

The struggle is not given up easily though. There has appeared over the last twenty years, the engineering discipline of Software Process Improvement (SPI) which exists to create software that is absolutely fault tolerant. With a growing interest in SPI, the software industry is making daily strides in perfecting code creation processes, which contain ever-smaller fractions of the errors once encountered. Several of these SPI regimes are now widely accepted and practiced throughout the world. Their ability to dramatically step up the quality of software has been demonstrated in countless cases, a prominent one of which is the U.S. Space Shuttle Program. It is reported that between the mid 1970's and 1993, SPI initiatives reduced the number of software faults known to exist in launch software to zero from over two million lines of software code. The need for high reliability software in aerospace, aviation and undersea computing systems has provided a powerful motivation for SPI regimes, which are no longer considered unprofitable undertakings.[11] Most of these areas of implementation share a common characteristic of either extremely high monetary risk or they support software which is critical to the lives of the users or both. In the case of consumer software where the

development process is driven by speed to market and constant innovation, SPI initiatives are not nearly so apparent. (HERBSLEB 97)

There are at least three reasons SPI should be brought into the development of Damage Control Software. First, using a vital to life and high cost of failure criteria, it should be pointed out that by extension, aircraft which are designed with SPI affected processes can only stay in the air or be safely recovered by an aircraft carrier which can maneuver, particularly when away from coastal waters of friendly nations. While the ship is fighting fires onboard, the ability to land aircraft may be lost. Secondly, reliability of damage control systems is the prerequisite for any new technology introduction. Millions of development dollars are at risk if system users distrust the technology and shelf a new system due to delayed release or performance which fails to meet specifications. Reliable systems take time to develop and the fleet is impatient. Lastly, a new reliability paradigm for software is now needed to improve the fleet's expectations. Innovative young people will hardly be attracted to occupations such as damage control if modernization and automation are smothered by risk averse, technology suppressed, last minute solutions to current manpower reduction initiatives. Aircraft Carrier damage control software is an excellent place to begin this paradigm shift. SPI forms the foundation level technology (Figure 2) that can enable extreme reliability needed to automate manpower intensive manual tasks for damage control. Putting upwards of fourteen hundred personnel into repair lockers in emergencies like General Quarters will not be an acceptable standard once DAMAGE CONTROL computers are designed that can act in our place reliably.

1. What is the Capability Maturity Model?

The Capability Maturity Model (CMM) is a Software Process Improvement (SPI) regime that provides a comprehensive, methodical and thoughtful approach to the business of designing and creating software. In the years since it's inception in 1991, CMM has become the dominant SPI initiative in the military aviation and aerospace industries. Watts Humphrey and the Software Engineering Institute (SEI) base CMM on studies at Carnegie Mellon University (CMU) into what process ingredients make up the most successful software development organizations. Beginning with the tenets of Demming's Total Quality Management (TQM), SEI developed a framework of practices known as Key Process Areas (KPA's) to apply to nearly any software development system

which has been shown to make the outcome of the process better. While the 1993 release of the CMM was stated to be a baseline document, subsequent revisions of it have tended to expand on the original themes by adding the disciplines of Software Acquisition (CMM-SA), Systems Engineering (CMM-SE) and Integrated Models (CMM-I).

2. How does it work?

The CMM is a five-tiered approach to improving the software development cycle by improving the processes of the organization using it. Five to ten evaluators normally from outside the organization are hosted for one to two weeks as they evaluate the software development processes of that organization. The criteria for the evaluation is embedded in the set of KPA's that apply to the level of certification sought by the organization. The organization can conduct informal internal "self-assessments" to prepare for certification. It is in the organization's best interest to lay everything out in an open, honest way that will help the assessors get at the fundamental processes and to identify those which are positive in light of the criteria and those which are counterproductive.

The five levels are as shown in Figure 4 and represent a continuum of Key Process Areas which when instituted, represent attainment of the indicated level of process maturity. Attainment of a specific level does not indicate that an organization is performing any better than a lower level organization but that the elements are in place to attain more control over the processes. This is the indication that the organization is capable of producing more reliable predictions of final product output, timing and costs. Several Navy organizations have attained certification of level two or level three processes (Table 2). Most of these certifications were within the last 3 years due to the newness of the program and the time required for attaining each level. Organizations

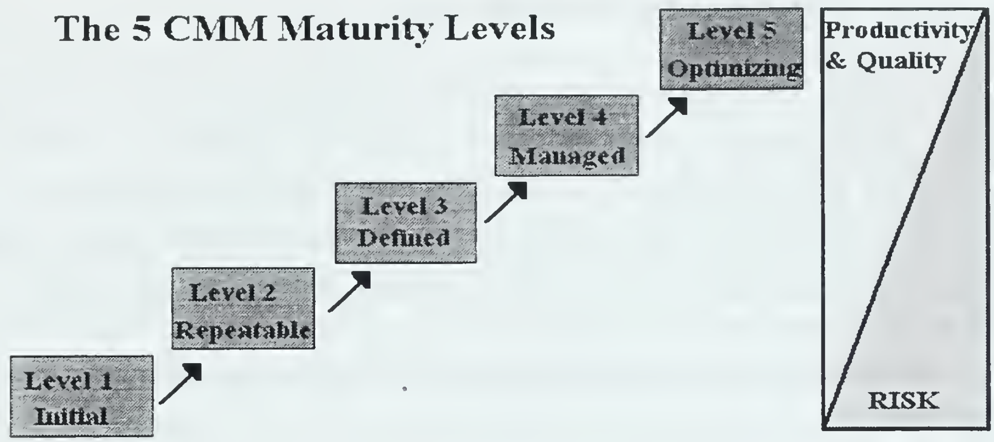

Figure 4. 5 Tiered levels of maturity give software-producing organizations a framework of process sophistication criteria to fit in to.

prepare for certification in a self-paced evolution to that higher level organization. The time normally expected to go from level one to level two is 24 to 30 months. Level two to three is expected in 18 to 25 months and so on. There are some companies that have taken as few as 12 or as many as 55 months to attain a single level. There are also companies that have reverted to a lower level after discontinuing some of the processes that had fulfilled the KPA's earlier.

Attained Level	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
Process Goal	**Initial**	**Repeatable**	**Defined**	**Managed**	**Optimizing**
Key Process Areas (KPA's)	Ad Hoc process: No predictable or identifiable path to progressive improvement. Success is based on "heroic" efforts of a few core contributors.	-Requirements Management -Software Project Planning - Software project Tracking and oversight -Software Subcontract Management - Software Quality Assurance Software Configuration Management	- Organization process focus - Organization process definition - training program - Integrated software management - Software product engineering - Inter-group coordination -Peer Reviews	- Quantitative process management - Software quality management	- Defect prevention -Technology change management Process change management
Examples of companies currently at this level	75 percent of US software producers	Naval Surface Warfare Center, Dahlgren VA	NSWC Dam Neck USAF Air Mobility Cmd	Lockheed Martin Ocean Radar And Sensor Systems Sector	Boeing, Lockheed, NASA

Table 2. Key process areas each contain many criteria to measure the processes for maturity

3. How will CMM benefit the Navy?

The CMM was developed beginning in 1986 at the behest of the Department of Defense, which had been under fire from the GAO for failing to implement basic improvements advocated by DOD's own studies of its software development processes conducted as far back as 1983.[12] DOD has a long track record of failed programs and initiatives that have ended a bust. Often the culprit of these failings is software which under performs specifications or simply is not completed in time to coincide with budget and resource constraints of the original plans. Examples of these failed or overrun projects include the Navy's A-12 and improvements to the F-14 Tomcat and F/A-18C/D Hornet. CMM can help to alleviate the frequency of these failed projects by building into the process of software development, a work environment that is conducive to repeatable, defined, managed, and finally optimum performance in the execution of software development projects.

4. What is the latest trend and future expectations of the CMM?

In the eight years since it's initial release, the CMM has assumed a prominent place within the aviation and weapons control sectors of the military industrial community. It has also grown and been adapted to civilian organizations outside this domain, particularly in the electronic sector and in high reliability industries such as aerospace, weapons, and precision test equipment. As of this writing there are at least 5 different CMM adaptations to apply the original model including the recent addition of "People CMM." International application of the CMM knows no bounds and includes Australia, England, India, Germany and Italy to name a few. There are 75 organizations listed on SEI's directory of users of the CMM. As of February 1998, there were over 600 organizations that had reported to SEI to be assessed at one of the 5 levels. Seven of them are listed as level 5 certified and these are only a fraction of the actual number of organizations using the CMM.[13]

5. What role do training institutions such as NPS play in the CMM process?

The Naval Postgraduate School can have a positive role in championing SPI for the Department of Defense as a whole. Acting from an unbiased perspective with a

technology centered curriculum NPS is in the unique position to investigate, and evaluate the yield of SPI programs to determine what value each product has to the DOD. By introducing it's Computer Science and Information Warfare students to the various SPI initiatives, NPS can indoctrinate much of the acquisition community and future requirements specifiers in the conventions of what must be ventured and can be gained from such programs. Finally, through thesis research, students can help to contribute to the body of knowledge regarding best practices and products are available to the DOD.

6. How does the CMM or SPI in general apply to Aircraft Carrier design?

All of the major Software Process Improvement regimes now in use allow the customer to get better software products, produced with optimal quantities and quality levels of labor within more predictable time constraints than could have been attained without CMM. Organizations that have attained some level of improvement are better able to communicate with fellow organizations that have an understanding of the same KPA's.

Aircraft Carrier systems are being pushed toward integration more than ever before. "Stovepipe" is a pejorative acronym for ideas and systems which are out of date and unable to contribute to the integration and automation of information systems. CMM encourages increasing levels of awareness and eventually direct involvement between organizations to attain increasingly better coordination, control and productivity within each organization.

7. What are the organizations likely to be part of the delivery team for CVX?

CVX will attract many of its predecessor's commercial contractors to the bidding table due to the incremental nature of aircraft carrier design. Several innovations that have made their way into CVN 75 and 76 signal a modernizing trend is already underway. Makers of the navigational, ships control and communications systems have gone to computerized versions of their original products. The ships control console designed by Sperry Marine on CVN 75 sports video monitors and touch screen controls in the places where CVN 74 had mechanical gauges and illuminated toggle switches. Fiber optic cabling through the ship now includes "blown fibers" which is a customized replacement

for what was previously mechanically laid and mostly copper cabling. The internal telephone systems that have been replaced on all the carriers are capable of digital data rates and have been networked by Lucent Technologies for scalability and future growth. Compaq and Oracle have joined forces to create the first computer classroom onboard CVN 75. A substantial amount of the weapons and sensor systems are designed by Martin Marietta, Lockheed and the Raytheon Corporation, organizations which have knowledge of and demonstrated commitment to the CMM.

8. Case studies of large organizations that have put CMM to use.

There are many examples of companies that claim to be more productive and in control of processes with the CMM. No organizations have been discovered by the author which have tried CMM and discontinued its use due to failure of the concept. There are however organizations which have gone down a level after evaluation.

9. How will CMM benefit government contractors?

Contractors wishing to participate in the implementation of the CVX design will find it necessary to attain some level of SPI in order to answer the needs of the government and prime contractor for a measurable ability to meet requirements within certain risk parameters. In return, these companies will find that they are better able to present reliable and profitable estimates of performance with a higher level of credibility than their competitors regardless of pricing and with reduced emphasis on their time constraints. Newport News Shipbuilding (NNSB) will play the central role in designing and building CVX. Within NNSB, information technology leadership is developing a "Process Improvement Program" that proponents believe will permit NNSB to "produce effective reliable software consistently on time and within budget". The specific model that will be adopted has not been confirmed but the five-tiered CMM is considered the best fit at this preliminary stage. Internal company policies preclude disclosure of NNSB's timeline for implementing the initiative. Most of the companies that have attained level 2 and level 3 certification have done it within 24 to 48 months. If NNSB were to adopt within this time frame, they could have a level three certification by 2003 and be in an exceptionally strong position to help develop the software products provided to the Navy with CVX in 2006. Without an SPI framework in place, NNSB would continue to be a major player in most decisions but would not be able to leverage their

conceptual insight to capitalize on future contract options requiring reduced risk and process maturity. More importantly, NNSB could not be as certain of it's own limitations with respect to schedules and software process completion. In competitive bidding with CMM level 3 companies, NNSB would be considered equal or less reliable in it's risk assessment values and therefore could expect to lose out on bidding due to their need for larger safety margins added to most CVX software work.

Despite clear indications that CMM could help the NNSB Company in many ways, the company is not yet ready to commit to embrace SPI by what has been demonstrated. The company is currently evaluating the impact of undertaking an SPI program and has assigned a small group from their software group to evaluate the options and select a program. The initial cost and training required to start up the program require scrutiny at the highest levels before a decision is rendered. One well-known and often cited pitfall to CMM implementation is lack of senior management buy in. IT staff at NNSB are currently advocating a hybrid approach to upper management.[14]

10. Evaluation

Software Process Improvement by itself is not a direct contributor to better damage control. It is however, the means by which software reliability and risk management in the software process can be incorporated to ensure the best possible products are delivered to the fleet. The only way to ensure automated systems are reliable enough for use in life threatening circumstances is to insist on first rate requirements analysis, a full design cycle with adequate development and testing time and configuration control to ensure the final product is acceptable. Unreliable equipment is of no value to the fleet as is evident in the survey responses.

a. Manpower

The manpower savings of software process improvement are not directly identifiable among the fourteen hundred personnel of the carrier's Damage Control organization. Collectively however, SPI with the applications it enables is an indirect contributor to manpower reduction. Initially, the CMM requires additional personnel to accomplish the oversight roles required for refinement of processes. Eventually, though, the reduced amount of corrective work that must be done to correct errors detected in

validation and user trials will return a substantial portion of the man hours extended. (Scores 2 of 5 indicating manpower savings is a possible outcome of SPI)

b. Preference

While no specific technology is identified with SPI in the user survey, reliability, user friendliness, and proven performance are graded on their value of importance and all three are expected attributes of the CMM on software processes. For this reason, a score of 4 out of 5 (desired) is warranted.

c. Integration

SPI directly enables integration of other previously incompatible systems. (Scores 5 of 5 for integration)

d. Reliability

One major emphasis of SPI is to improve the reliability of software which will support the other technologies which it integrates. (Scores 5 of 5 for reliability)

e. Backfit

SPI cannot be directly backfit to previously documented software. It is a technology best applied from the beginning of a design process. SPI however can be applied to organizations responsible to update programs. The greatest value of SPI however is in reducing risk and uncertainty in the development of new programs.

f. Maturity

As an enabling technology for the maturity of software processes, the CMM itself is not a fully mature technology. It however has achieved a level of stability and acceptance as a standard on par with ISO9000 SPICE and is the core technology for several variations on similar Key Process Area core ideals. (Scores 4 of 5 for maturity)

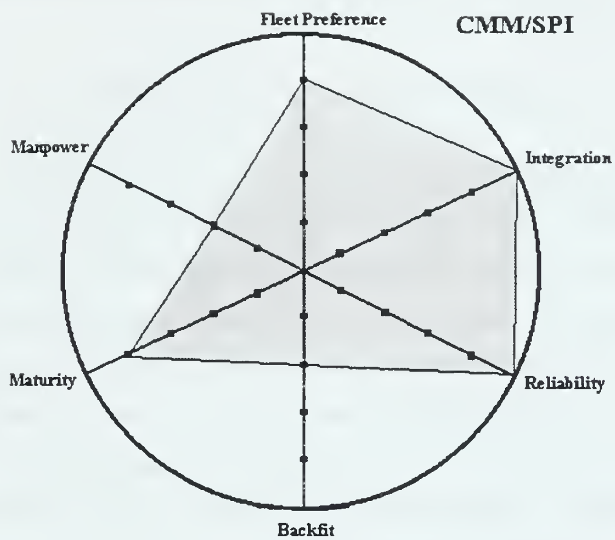

Figure 5. As an implementation strategy, SPI does not demonstrate Backfit or Manpower improvements over ad-hoc software development driven processes

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III. LITERATURE REVIEW: REPAIR LOCKER TECHNOLOGY

A. OVERVIEW OF APPLICABLE TECHNOLOGIES

One of the most commonly recognized obstacles standing between the sailors and timely improvements to shipboard technology is tradition. The technology to drive a ship from one port to another without human intervention or mishap not only exists but has been in use onboard commercial vessels for several years. Similar advancements have been made in the area of damage control with training, sensors, communications, fire-fighting equipment and automatic extinguishing systems. In order to take full advantage of the benefits of technology in the damage control world, the Navy must be ready to accept a revolutionary approach to the manning of its ships. Rather than man a new aircraft carrier with the manpower list from the previous carrier in hand, we must be ready to examine the tasking and events that could occur on CVX and provide manning only where the task proves it is needed. Phone talkers, message plotters, messengers and investigators would not have been conceived of had reliable touch screen displays and networked digital sensors existed in the 1960's. Imagine the space shuttle going into orbit with phone talkers and message plotters carried onboard to parrot every decision and plot each change in the situation as the astronauts attempt to survive in space. Not only would they take up valuable space, but also it is probable that even working to the best of their abilities, they would eventually add to the difficulty of communicating vital information with the ground rather than aiding it.[1]

B. DAMAGE CONTROL INFORMATION DISPLAY

Currently, the technology used in data display and tracking within repair lockers is not much different than it was in the 1960's. Grease pencil plotting boards and flip-panel displays line the bulkheads. These simple devices provide a highly reliable graphical plot of damaged and surrounding areas of the ship. These charts must be modified on a periodic basis to stay semi faithful to the ever-changing layout of the interior of each ship. They are plastic coated for reusability and ease of plotting. The charts are approximately 27" by 38" and number in the hundreds throughout the ship depending on the size of the ship and number of critical systems onboard. There is normally a set of drawings in each

of the carrier's twelve lockers, a local set in each of approximately 40 unit lockers, stored master sets and a full set for Damage Control Central.

Features of the charts are durability, portability and size to accommodate discussion and marking by several people simultaneously. The adverse side of these boards is their limited very compact scale which limits precise notes, the perishability of the info on them; awkwardness of handling them, and the requirement to have manual plotting personnel in each locker to update them. Additionally, they require an overhead source of light to adequately use them regardless of electrical power conditions. Damage control event keeping and dynamic status of forces information cannot be compared on charts at two separate locations therefore, if the plotter in one locker misses some information, it can not be seen by other plotters to correct.

1. Flat Screen Displays and Touch Screen Technology

Since the1960's, video monitors have advanced dramatically. With the government mandate for the television industry to shift entirely to High Definition Television (HDTV) a digital format by May of 2006.[2] it appears the improvements and choices will only increase. There are many choices to be made on the type of display which would best serve damage control needs. Within our overall technology concerns of this thesis, there are many additional aspects of video monitors which must be considered. (Figure 6)

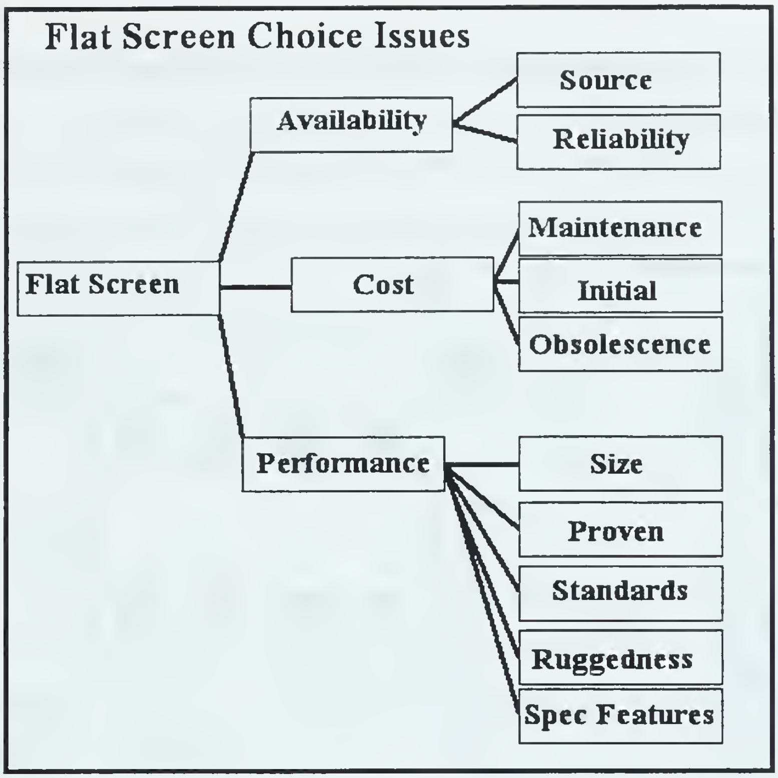

Figure 6. Taxonomy of the flat screen display purchasing tradeoffs

The three main dimensions for our selection would be cost performance and availability of each product. Within performance is size. In order to adequately replace the existing DC plot boards, the largest of available flat screens are required. The tradeoff for large displays is increased cost. Current large screen monitors are full color gas plasma screens of up to 42 inches viewable screen and a 16 to 9 aspect ratio between width and height which is consistent with the HDTV format. They are generally six inches thick (Figure 7).[3] An enabling technology for training, control and communications, these highly efficient devices can be used in nearly any application and can operate on permanent or emergency power. The manufacturer warns that they do however, currently "present a problem with respect to Electro Magnetic Interference". A 55 inch version is expected to be available in the near future but the manufacturer has not developed a monitor around it yet. The glass panel at the heart of these systems is being rapidly developed by several Japanese manufacturers and hardened by U.S. vendors for sale to the DOD. Although the cost of these displays can be expected to nosedive when the HDTV standard comes into effect in the United States, the current price for one 42"

unit is about $15 thousand dollars. In quantities of 100 or more, the price goes down to a "mere" $13 thousand.[4]

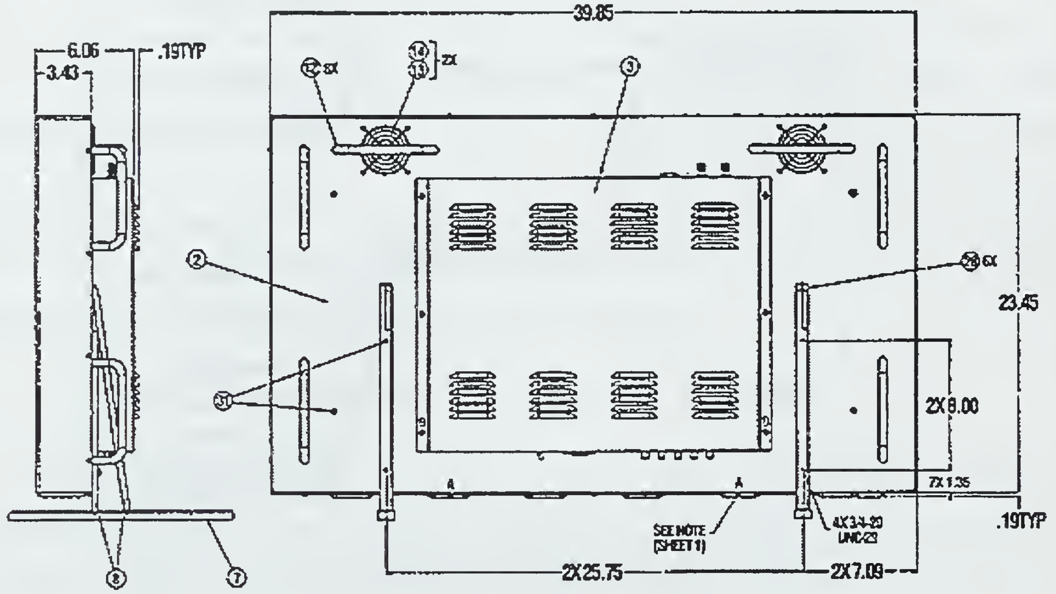

Figure 7. 42 inch Gas Plasma screens which meet digital and HDTV standards

2. Proven Reliability?

Active Matrix Liquid Crystal Display's (AMLCD) displays already supplied by at least five commercial sources to the DOD are employed in some of the most reliability-tested positions on carriers. The United States Display Consortium[5] (USDC), created by industry and the Department of Defense's Advanced Research Projects Agency (DARPA) ensure a domestic Flat Panel Display (FPD) manufacturing capability. A Military and Avionics User Group (MAUG) was established by companies who have developed criteria for development of these products.

Consider the fact that on several aircraft carriers and submarines since 1994, FPD's have been trusted to display course, speed, wind velocity and other vital navigational data as these ships execute complex underway replenishments safely and

confidently. They are also used to relay "life or death" ship's control data used to safely land aircraft on the flight deck. These displays are highly reliable and provide concise data with accuracy and speed on a continual basis underway. The reasoning behind flat screen displays as opposed to CRT's is the ability to install them in narrow passageways and small compartments as repair lockers commonly are. These displays are luminescent so they can operate when normal lighting fails.[6] They have the ability to store information and can be networked to pass information and control between units in case of a failure in one or another. The power and low heat dissipation requirements of these units as well as their shock tolerance make them much more practical in a hot, combat environment such as during damage control operations than their CRT counterparts. The largest AMLCD currently available is 20.1" with a 4:3 aspect ratio which is not HDTV Standard (Figure 8). This is a more attractive option than Plasma Gas Displays for a shipboard environment from both an EMI and a price perspective. A thirty inch version is expected to come out soon but it is currently too expensive to attract customers on the commercial market. The 20.1" sells for $10.5 thousand dollars to $12.4K depending on qualification needed. In quantities over 100 pieces, the price goes down to $8.4 thousand per display from $9.3 thousand.

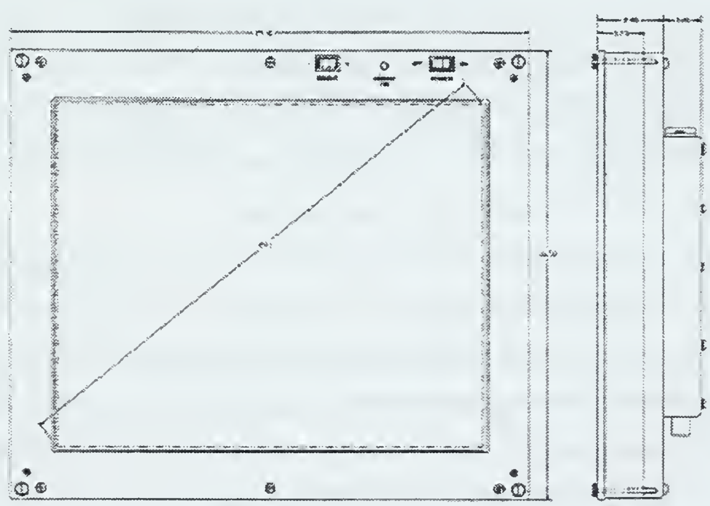

Figure 8. 20 inch AMLCD (L3 Display systems graphic)

While the protocol to employ in these networked displays remains to be determined, it is conceivable that TCP/IP could be used to communicate between nodes.

This would make them available to communicate in other ways as well as browse for location data and to report personnel musters and other normal repair locker communications. Symbology and packaged messages via hyperlink style selections would provide the structured communication that is now done by voice channels. Direction and "what if" scenarios can be done via remote "whiteboard" style plotting from any other location while all idle lockers are silently and continuously appraised of events via their own networked display. Much of the technology to accomplish these actions is already being used around the world in Internet chat rooms. In addition to the utility of these displays in an actual emergency, their use must also be considered for the training aspect of damage control.

3. Is the Fleet ready for Flat Screen Display Technology?

Reporting and communications between lockers can be recorded and played back for review of actions exactly as they occurred. It is not surprising that flat screen displays were the most highly rated potential technology in the survey of 63 senior damage control specialists on carriers around the fleet. (Appendix B) The high utility of these displays is what makes them so beneficial in the repair lockers. A single input terminal in Damage Control Central can receive and distribute rapid damage assessment information throughout the ship. By making these displays touch functional, local locker personnel can deliver information to central control without continuous chatter and repeat back on conventional audio circuits. This alone makes close to 100 'phone talkers" unnecessary throughout the ship. It would also lessen the noise and confusion in the cramped lockers while several people talk at once.

Currently, the weakest aspect of these devices is their unproven reliability when coupled with a computer and power is interrupted or in the case of an electromagnetic pulse in the event of a nuclear blast. Current methods of alternate power sourcing, automatic data saving and redundant data storage make the probability of a complete loss of operability little more plausible than the old grease pencil plotting boards. Until the system proves itself however, traditional plotting boards could be retained for such unexpected contingencies. Battery backup and network assurances are the now highly reliable and warrant at least a strong exploration of the technology.

Another variety of flat screen display at reasonable cost is the PPC-102T currently offered by Advantech of Taiwan.[7] It is in fact a PC and screen in one component which

is currently being developed for standard PC based applications which support IT 21 initiatives.[8]

4. Evaluation

a. Manpower

Flat Screen Displays with touch screen capability promise to reduce the number of personnel required to operate the Repair locker by eliminating the need to converse with DCC while updating the plot or screen. Updates from one location would be reflected on other locations and acknowledged as they were received. The need to write on displays would be eliminated by touched in entry of data which would control the views and store a record of the entries which could be reviewed for training and critique. This represents a reduction from the four people Plotter, Locker Leader, Phone talker, and Messenger down to only the Locker Leader and Messenger, a savings of 50 percent. (Scores 5 of 5 for manpower savings of over 30 percent)

b. Preferred

The survey of Fleet users found near unanimity in the need for flat screen displays. The comments are noted in Appendix C but with the exception of questions of ruggedness and reliability, FSD's were far and away the most popular technology of the four specifically identified in the survey. (Scores 5 of 5 for user preference of "Highly Desired")

c. Integration

In flat screen form and with the HDTV standard coming into much wider usage, this technology entirely removes the need to convert digital data on the ships LAN into analog representation required of CRT monitors. It also integrates all networked sources of data into the locker making distributed computing and data warehousing solutions available to the locker when it is most rapidly needed. Lastly, training software and visual training aids can be distributed to damage control parties throughout the ship effortlessly and simultaneously to maximize the precious time provided for these events. Innovation of this technology promises to take the locker to the fire via video so that

more people can work the problem and traditional verbal communications are supplemented with visual information. (Scores 5 of 5 for integration since it is entirely modular and as an enabler of other technology)

d. Reliability

Reliability of this technology is rapidly being overcome by hardening of equipment, alternate sources of power and easy sparing out of defective units. The self contained nature of terminals and their shock and heat resilience makes them as dependable as manual plotting. Back lighting and the ability to zoom, copy and pass information between nodes on the network are features which boost the reliability of plotting function substantially. (Scores 4 of 5 for reliability since it adds features and reliability)

e. Backfit

The ability to backfit this technology to previous carriers is one of the more promising of the technologies. Currently, all carriers are being outfitted with fiber optic networks and substantial computing capabilities. Once the architecture of these systems is developed, all carriers should be able to achieve the same modernization's without cost or technical limitations. It is possible that a large scale backfit could provide significant savings in the per ship cost. (Scores 4 of 5 for backfit which should be available at a la carte cost with no delay)

f. Maturity

Although industry standards are expected to remain turbulent for the foreseeable future, this technology has achieved a level of maturity which should allow it to transition into reality with little technical difficulty provided an acceptable standard is selected which foresees the innovation which will be brought on by HDTV. (Scores 3 of 5 for maturity of available but unproven performance)

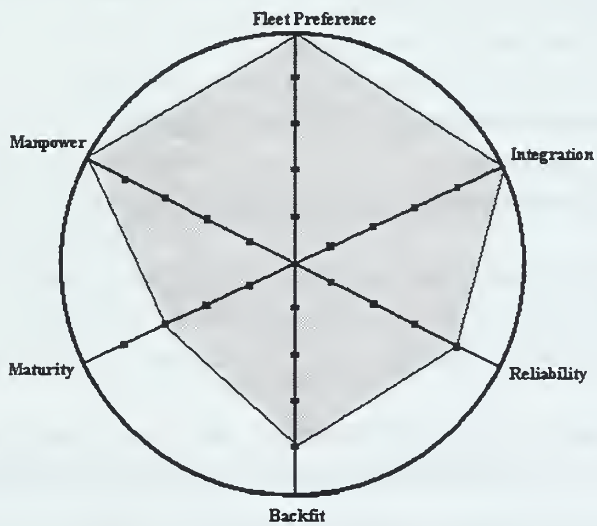

Figure 9. Flat Screen Display scores best of all technologies reviewed

C. VIDEO TELETRAINING (VTT)/ VIDEO ON DEMAND (VOD)

An extraordinary amount of the training is done to prepare the crew for Damage Control on aircraft carriers. The average crewmember upon arrival at the ship has been trained in the fundamentals of fire fighting, flood control, chemical, biological and nuclear decontamination. Part of the ship's indoctrination will also include 2 or 3 days of fire fighting trainers and immediate enrollment into a standardized Personnel

Qualification Program. Normally, all crewmembers are required to qualify for basic damage control within three to six months of arrival. For the remainder of a three to five year tour onboard, the individual will be expected to move steadily up the qualification ladder, achieving proficiency in every position on the Damage Control Team up to the Scene Leader. Several more senior positions are normally assigned by the person's billet on arrival. Reading, Personnel Qualification Standards (PQS) lectures and demonstrations are used to accomplish training for all of these personnel. Testing of skills is by oral boards, written test and demonstration of skills. Some of the difficulties of conducting this training are:

- Incompatible hours between trainers and trainees
- Lack of motivation of individuals to attend and participate in training
- Inconsistent quality of trainers
- Lack of expendable training materials
- Poor tracking of completed training for individuals
- Constant turnover of most experienced personnel
- Minimum manning
- Limited classroom space, space constraints on ship favor many small training rooms
- 24 Hour schedule interferes with large group training and set hours for lectures.
- Diverse training requirements of crew dictates many varied topics of study

To counter many of these difficulties, there are many innovations in Video training technology being tested throughout the fleet. Integration of the Video Teletraining and Damage Control technology roadmaps will combine training technology under one central schema will facilitate outfitting similar technology areas with the needed assets to support training. This technology should be developed on present carriers to determine the best of all systems.

By determining the limitations and advantages of many offerings of commercial suppliers, we can make a clear and productive determination of which technology to use. Assumptions about the limitations of future Video teletraining and teleconferencing systems may not be valid ten years from now however, the interim solutions using what is available will ensure that we are ready to select the best technology when the time arrives.

1. How VTT/VOD would work

Bringing the flat screen displays in the repair lockers online can provide one portion of the DC training suite. System logs and time lapse development of drills and events provides another aspect of training that can be delivered. The technology to deliver lessons to qualifying individuals on client PC's could be made available from a server accessed from anywhere on the ship on demand.[9] Separate lessons covering varied subject areas could be channeled simultaneously and accessed by one or several individuals with specific training needs. Network technology for VTT is rapidly maturing with some standards already in use around the fleet.[10] None of these training systems was included at commissioning as different carriers developed suites out of compartments converted from other tasking. The following changes to the fleet are expected to enhance the feasibility of VTT/VOD:

- All Carriers get CAIII enabling CNET Electronic Schoolhouse Net to reach all Carrier Battle Groups
- CVN-75 Pioneers Compaq/Oracle VTC Classroom in 1999
- Planned to add GBS to BG level by 2002?
- Desktop VTC can be delivered even in Condition 1 steaming.
- Increased numbers of computers at sea makes fiber optic LAN distribution possible

2. Is The Fleet Ready For Video Teletraining?

In her discourse on the effectiveness of video teletraining, Shawna McKenna concludes that the form of training is not as important as the quality of the message and it's delivery to effective learning.[11]

> And while interactive multimedia (and technology-based learning generally) may be exciting technically, it does not automatically lead to better educational programs. Good instructional design is good instructional design whatever the medium.

Since video teletraining on it's best day would then be more effective than a lecture on the same material given with only average interactivity and content, it would be more effective and consistent to record video teletraining with only the best trainers and

to facilitate them in later training sessions with knowledgeable but less experienced training assistants to field questions and spur critical discussion. By providing training personnel with the best techniques and most appropriate forms for each portion of their training role, Video Teletraining can be tailored to the specific learning objectives and be fine tuned from that point.

3. Evaluation

a. Manpower

Video teletraining results in more exposure by more personnel to a single trainer. Videotape stored lessons provide additional training and reduced trainer hours. Maintenance of VTT facilities may require additional man-hours but should be divided equitably between other video tasking using the common equipment. (Scores 3 of 5 for "some manpower reductions expected" on Figure 11)

b. Preference

While achieving the strongest level of agreement of the seven technologies surveyed, user preference for Video Teletraining was diminished by the occasional perception of one-on-one training being eliminated as a result. The question did not state that one-on-one training would also remain in place. However, live demonstration is expected to remain a primary delivery mode. (Scores 4 of 5 for user preference indicating "desired". Low frame rate is the main user VTT weakness)

c. Integration

Based on the current progress of Video on Demand (VOD) and H.323 standard video protocol, VTT is expected to integrate on the ship's LAN backbone. Bandwidth considerations make it a considerable drain on network resources. IPTV as tested in the lab proved to be a reliable and robust application to all stations in the local LAN for point-to-point and multi point sessions. White boarding and audio came through without undue preparations. This technology requires no special equipment aside from the camera and video capture software that was purchased for less than two hundred dollars. (Figure 10) Storage and applications servers are available for most operating

systems. IPTV and several other COTS products are consistent with DII/COE and compatible with IT21 specifications. (Scores 5 of 5 for technology integration indicating "fully modular/enables other technology")

d. Reliability

Not yet airtight considering bandwidth needs/availability, however, this can be mitigated at the cost of quality. Reliability of the VTT transmission is best in the local LAN environment due to fewer chances of the wide band signal encountering network slowdown. DC training can be confined to the local ship's network and retain most benefits. Added features of this technology over stand-alone systems are potential for real time usage, ability to port training to full time CCTV and reuse of ship's computer workstations if available and Windows 95 compatible. (Scores 3 of 5, adds value but not reliability due to bandwidth sensitivity)

e. Backfit

Due to the cost of outfitting all previous carriers with identical systems to achieve fleet standard, backfit is not recommended in all cases. Nonetheless, backfitting should not be difficult on any previous carrier. (Scores 4 of 5 for backfitting. Can be included separately)

f. Standards

One of the strongest candidates in technology for standards due to the strong industry push to achieve them early. Internet Videoconferencing H.323 (an extension of H.320 based upon the IETF's real-time Protocol (RTP) covers videoconferencing over narrow-band WANs and also over LANs. A group of accompanying standards accomplishes sound, back channel and white board standards. [12] (Scores 3 of 5 for maturity indicating "available but unproven" maturity).

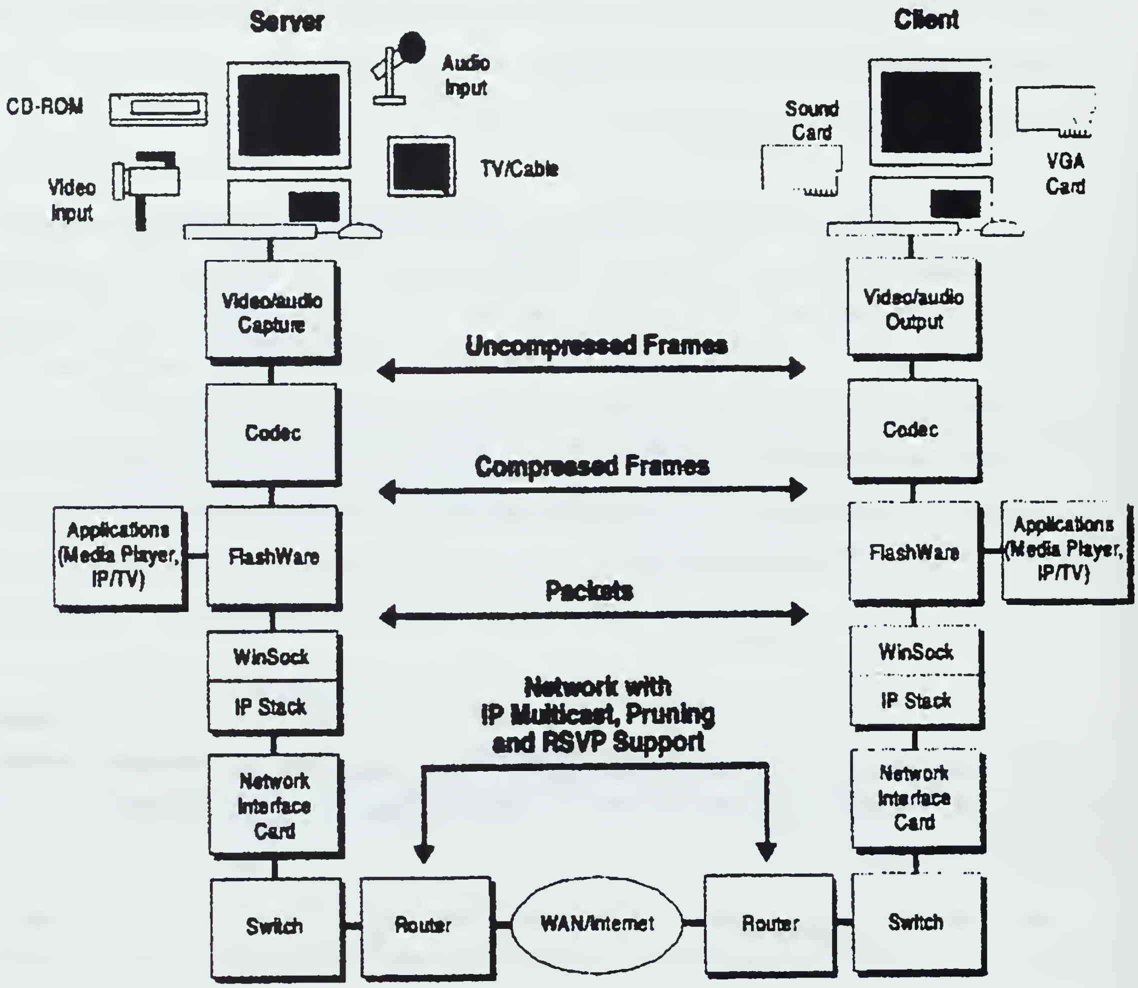

Figure10. An example of the COTS IPTV product which provides Video on Demand to the desktop.

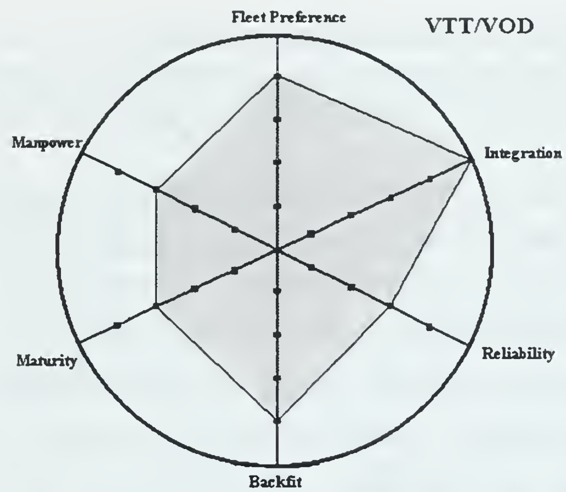

Figure 11. A well developed technology, VTT/VOD was higher rated in the fleet survey and scores best on Integration and Backfit capability in the Kiviat graph.

D. DECISION SUPPORT SYSTEMS

There seems to be no shortage of studies that have touted the use of Decision Support Systems (DSS) in tasks ranging from hospital emergency rooms[13] to repairing a Diesel Locomotive.[14] The main goal in employing a DSS is to collect expert knowledge into a rule based system. The system given a set of current or hypothetical conditions ideally can determine what is the right decision if all criteria have been specified correctly and within the domain of information that the DSS addresses. In fact, thousands of DSS's are in use around the world at the present time. It is also true, that due to changing conditions, poorly specified expert knowledge or lack of "buy in" by the users, many of these systems sit unused as monuments to failed execution.[15]

Damage control situations on naval ships have all of these characteristics that call for the assistance of expert systems:

- A relatively narrow knowledge domain (assess, contain and suppress damaging effects of fire, flooding and contamination on ships at sea with a fixed set of tools and resources.)
- Short span of time to control events
- Large body of expertise to work with

- Common/repetitive rules to respond to events
- Multiple options for circumstances with a single best solution.
- The need to experience "what if" scenarios prior to the real thing

For damage control functions on ships, there are a multitude of studies and recommendations from over the years that recommend the use of tactical decision aids in operating the complex damage control environment. A 1996 study by David L. Tate of Naval Research Laboratories concludes, "by simply following the actions recommended by the decision aid, the user is able to respond quickly and correctly to the problem". Tate goes on to outline how such a system can be built using the C Language Production System or CLIPS which is an expert system development tool used by NASA to develop human expertise models. The distinguishing feature of Tate's study is the inclusion of smart sensors to directly influence the use of the knowledge base. He contends that by allowing sensors to be "Tagged out" or thresholds of those sensors to be dynamically altered due to fortuitous events, that the DSS can overcome many of the inflexibilities which would prevent a non-smart network of sensors from achieving user "buy-in".[16]

Another study by NPS student[17] William Carney detailed both a model and method for creating DSS's for damage control. Since 1991, when Carney's model was developed, tremendous gains have been made in computing software and hardware. In the time since his thesis was printed, PC based microprocessors have increased from 25 MHz to 550 MHz and typical system memory has gone from less than 4 to over 100 Megabytes of RAM. Typical hard drive storage has increased from 40 Megabytes to 10 Gigabytes a 250 fold increase! Yet, Carney's study resulted in further expansion of the body of knowledge. Still no active Decision Support System is in use yet for shipboard Damage Control. The nearest system to an actual DSS for damage control is the IDCTT or Integrated Damage Control Team Trainer that uses DSS type scenarios to verse Damage Control Personnel in combating simulated events.[18]

The most important aspect of any damage control technical enhancement such as a DSS to users has proven to be reliability. From this, we can infer that a DSS must be able to be updated to reflect new knowledge or learning to be trusted as "the expert" in life threatening situations. Obsolete information, if not correctable, rightfully diminishes trust in that system and soon causes it to be set aside as a distraction to time sensitive work. Systems must be able to learn or be updated within the environment. In order to meet this requirement the system must be responsive to input while at sea and must be

able to accept input from the ship's LAN. This would address the main shortcomings of a static DSS not identified in any of the readings uncovered to date. It should be noted that updates to the system can threaten its functional stability. An archive or safe backup mode should be available to restore settings from known good versions.

An exemplar DSS using the VP Expert software package is included in Appendix A. This short rule based system example demonstrates in one node, the potential to generate a web driven rule based decision support tool for use in repair lockers using COTS software. This model could be learned and put to use by onboard personnel on existing computers. It does however, leave much to be explored in the way of expert implementation and structured programming. These aspects are addressed in the earlier section on the CMM. This model is also best supported by the earlier section concerning 3-tier systems architectures.

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IV. LITERATURE REVIEW RETHINKING THE ROLE OF DAMAGE CONTROLMEN

Current outfitting of DC personnel is very similar to that of a civilian firefighter. The complexity and immediacy of the Damage Controlman's tasks are perhaps more ominous considering the fate of the ship and crew as compared to the fate of a building and it's contents on land should either firefighter retreat from the task. Additionally, the Damage Controlman is never more than a few hundred feet from his "station". One of the greatest difficulties in firefighting on a ship is the communications path back to the Repair Locker. This is a crucial link for the safety and effectiveness of the Damage Control Team. The means of communication at best is a sound powered phone at the scene connected at the other end with the locker phone talker. Radios are sometimes used but sound quality and busy hands get in the way of direct conversation. When phones are not available, messengers are dispatched to and from the scene. These messengers are verbally briefed and also carry a damage control message blank. The message blanks are formatted with standard symbology. This means of communication often results in translation errors so messengers are trained and drilled to "repeat back" the information loudly and clearly to ensure it is received.[1] This additional communication takes attention away from the Repair Locker Leader (RLL) and from the Attack Team Leader while each of them are directing others in what to do. (Figure 12) The last resort in communications is for the Scene Leader to personally return to the Repair Locker to communicate directly with the RLL. To ensure that the Damage Controlman is equipped and supported with the best technology available, we can improve on many of the devices currently available to him on the job.

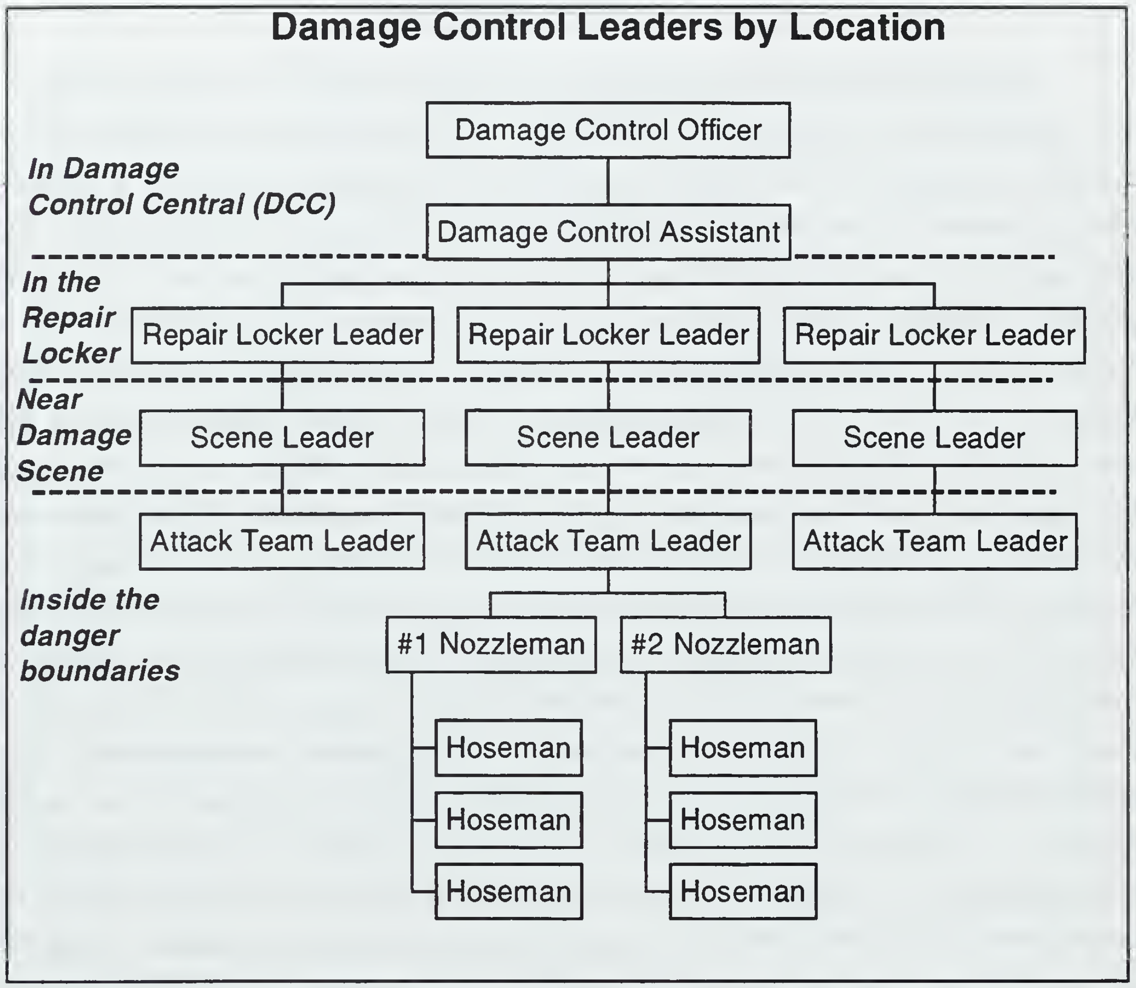

Figure 12. Typical Damage Control Organization (Leaders and hose teams only).

A. DEVELOPMENT OF A "SMART SUIT"

By incorporating the best available technologies into a suit similar to the firefighter's ensemble, it is possible to better equip the firefighter to evaluate, report and prosecute the damage confronting him or her. The numerous benefits of such a suit are limitless. We can however, examine a few of the technologies which are commercially available and are candidates for evaluation with our evolutionary model. Among the

technologies to be analyzed in connection with the Smart Suit are Wireless communications, Barcode scanners, and Head Contact Microphones.

The Navy Firefighting Thermal Imager or "NFTI" is a self-contained scope like device for identifying "hot spots" at the core of a fire. In it's conventional configuration this bulky device occupies both hands of the user and must be handled carefully to avoid breakage. The NFTI could be incorporated into a waist pack and eyepiece assembly to free the hands of the user, better protect it from shock and to integrate it with other wearable display devices.[2] The second innovation to the ensemble would be the incorporation of new Head Contact Microphone (HCM) and phone assembly soon to be released for use by the Naval Surface Warfare Center NSWC. Designers of the HCM claim that it eliminates speech distortions created by the OBA mask currently worn by firefighters. As part of a communications wearable computer, the user could converse with selected parties over radio and keep hands on the hose at the same time.[3] By integrating a wearable notebook computer with the NFTI and the audio link, it is possible that images and observations witnessed by the firefighter on the scene could be fed back to the personnel directing the fire fighting effort for remote consultation and direction.[4] This represents a paradigm shift from current runner/messenger communications in that it replaces manpower (the runner), increases reliance on Information Technology, and consists of commercially available hardware. Additional built in applications for barcode reading and video reach back could also be integrated into the smart suit based on existing technology. Possible applications for barcodes would be accounting of personnel, reporting of location by coded space labels and identification of piping systems and hazardous storage areas. Video reach back could be employed for damage surveying, remote hazard defusing and training by playback.

Some of the weaknesses of the Smart Suit concept lie in its unproven reliability in a harsh and threatening environment. It also incorporates wireless communications that is poorly regarded technology based on this perceived unreliability noted in our respondent's comments (Appendix C).

1. What are the enabling technologies of Smart Suit?

The concept of a Smart Suit is an exciting one. The standard navy firefighters ensemble provides a tremendous amount of protection to the wearer. However, it is cumbersome and insulates the firefighter so well that he or she may have no relative sense

of the heat level in the surrounding environment. When equipped with the complete ensemble, the firefighter has thick protective gloves and an Oxygen Breathing Apparatus or OBA strapped onto the front. The ears are protected by a protective hood referred to as "flash gear" and are shrouded by a thick pad that extends down from the helmet to defend against high heat.

• Contact Mikes	• Lithium Batteries
• Voice recognition circuits	• Digital sensors
• Video Eyepiece	• Barcode scanning
• Decision Support Software	• Video Simulation
• LAN	• Video reach back
• Wireless communications	• Microprocessors

Besides protecting the firefighter from the harsh environment these devices are a hindrance to communication, the tactile senses and free movement. We have accepted these limitations as tradeoffs to ensure the greatest safety of the Damage Controlman. Commercially available technology will permit a suit that also enhances the firefighter's sensory ability by providing a lightweight computer interfaced with equipment previously carried by hand.[5]

The future of Smart Suits is far from 100 percent assured though. The life span of batteries is a constant tradeoff with their weight and equipment performance. It is possible however, to expect up to three hours of activity from the current mating of Lithium cells with the Pentium II processors we commonly use in laptop computers.[6] This working time is substantially reduced by peripherals required to supply data to the central processor including the NFTI, fire finder, screen display, barcode reader and transmitter for the modem.

• Temperature dangers	• Location of assets
• Status of air supply	• Proximity of hazards
• Local water pressure	• Vital signs (pulse, respiration)
• Messages from control	• Hotspots, open flame detected
• Effectiveness of actions	• Communications with fire team

The question of ruggedness poses another challenge. Observing the activities of a typical fire team in action is a convincing argument against taking ordinary notebook computers into the fray. It is clear to see that impact hazards, heat and water are abundant

in this environment. Evidence of this is left behind after nearly every practice drill on the bulkheads and the equipment. For this reason, shock testing and hardening of each equipment component warrants thorough evaluation.

B. WIRELESS LAN

1. Background

Radio Communication has advanced greatly since the arrival of NIMITZ class Aircraft Carriers. The principal of transmitting radio waves within the compartmentalized interior of a steel-hulled ship has never been an easy problem to crack. Compartmentalization is the key to a ship's survivability in battle. Sound powered phones, a technology of World War II have met the demands of internal communications for more than fifty years. Ships were originally built with pneumatic speaking tubes, intercoms and literally thousands of sound powered headsets to aid communications throughout the ship. Reports were sent off the ship via Teletype at a 75-baud rate through dozens of channels and rows of Teletype printers and tape punch machines. Nearly all internal correspondence and record keeping was done without wired networks and delivered by messengers around the ship.

Since 1975, our ability to communicate within and out of the ship has increased dramatically. Most communication paths remain largely hardwired, but recent adoption of commercial wireless technologies has uncovered methods of getting around the compartmentalization hurdle. The role of wireless solutions within damage control has strong potential for growth.

The Navy has adopted portable communications to a greater extent than any other technologies to be discussed. Damage control technology broke the wireless barrier on ships beginning with the D/C Wire Free Communications (D/C WIFCOM) in the 1980's. Recognized for its ruggedness and resiliency in contingencies, the portable radio has enabled decentralization of damage control forces and even permitted D/C organizations between ships to operate. In order to set up damage control equipment, personnel must mass and prepare in an area away from the damage of smoke or flooding. However, there is no way to know where the damage will spread to. Occasionally, smoke or fire will drive locker personnel out of their Repair locker as was the case with the USS GEORGE WASHINGTON in 1993.[7] The capability for the team to retain communications on the

fly allows them to quickly regroup, reposition and control damage. This is where wireless communications really excels. Recent innovations in the size, power requirements and optimization of productive bandwidth have yielded new domains to be explored by shipboard users.

Currently the Navy is investing substantial amounts into a new type of wireless radio which has picked up where WIFCOM left off. In 1994 the Navy began evaluating this new system on board the USS EISENHOWER called Hierarchical Yet Dynamically Reprogrammable Architecture (HYDRA) Since then, the system has been installed on twenty additional ships. In 1996, HYDRA was installed on board the Smart Ship USS YORKTOWN. Reports from the ship have been very positive. In support Smart Ship's reduced manning initiative, the ship identified positions that may be eliminated or consolidated as a result of task consolidation and elimination. After a visit to USS YORKTOWN, Jack Frichtel, an Ericsson system engineer, said, "The ship has identified HYDRA as the single most enabling system onboard to reduce manning levels".[8]

Since 1996, the French Navy observed HYDRA in action on the USS EISENHOWER and decided to purchase the same system for their ships. The French Navy will use wireless communications to support new firefighting techniques. Included in the French version is the ship's Radiating Transmission Line (RTL), a below-decks wiring system which acts as the ships interior antenna. This is technology which goes back to the WIFCOM system. Thousands of feet of RTL are required to ensure complete radio coverage.

2. Beyond Radios

Building on the success of the trunked voice radio concept used in the HYDRA system it is theoretically possible to accomplish similar results to it's connectivity with data between networked computers on ships. Consequently, the capability to move through the ship while combating fire or flooding would eliminate the need for messengers and make the communications between the Repair Locker and firefighters more reliable overall. Considering the short range and available bandwidth within the ship, we could by extension, construct an RTL network resonant at frequencies to support a separate damage control wireless network. Like the HYDRA radios, each node on the network would have a unique transceiver ID which would permit sending or receiving through the network using the supervisory frequency and then being quickly

dispatched to a sub-frequency to communicate the subject data packet containing the damage control message. Bandwidth limitations of the channels would be in the 10 to 20 kilobit range which would accommodate rapid short text transfers between nodes. This is assumes a data channel which is the same as that available for the voice radios at a minimum.

Nodes would relinquish the channel upon completion of the traffic burst so that the next node in the request queue could be handled. Additionally, a quality of service or priority system could be incorporated into the request message. Spread spectrum and frequency hopping encoding of the transmitted signal can enable wireless LAN's and voice nets to operate at relatively low power levels thereby avoiding both interference with other RF equipment and snooping by hostile forces.

All of these assumptions do not consider the fact that wireless computer networks are widely available in a number of COTS solutions. Today's commercial solutions are generally not designed for use on ships and places where walls and great distance act as a barrier to RF transmissions.

The Navy is quickly developing integrated backbone based information systems onboard all classes of ships particularly the larger vessels like Aircraft Carriers. As a consequence of this integration, vast amounts of data useful to damage control can be found on these networks often passing in and around the Damage Control Central (DCC) area and near the repair lockers of the ship. Smart ship has taken advantage of these networks to provide consoles similar to those used to monitor the ships engineering plant in the damage control lockers. Currently, these terminals are used simply to track and communicate damage information between the repair lockers and DCC. The terminals are large and non-portable but serve as an example of what can be gained from integrating technologies to enhance damage control capabilities. Combining wireless technology and the portability of ruggedized laptop computers may soon be adopted for use in the damage control environment. The types of data that are available in ship's data centers include but are not limited to:

- Charts showing the location of fire fighting equipment, fuel and munitions, pressurized fittings, vital system controls, hidden entry and egress points, dangerous electrical sources, living spaces and lifesaving equipment.
- Supplies by quantity and location throughout the ship for use in an emergency.

- Lifesaving survival or medical information
- Cataloged techniques to control damage as developed over years of experience.
- The source, location and characteristics of sensory damage information gathered from detection systems throughout the ship.
- The operating parameters and current status of equipment throughout the ship.
- Direct information from other centers around the ship regarding external threats, progress of efforts and direction on what tasks are to be done.
- Training information, drills, instructions and administrative personnel accounting.

C. BARCODE TECHNOLOGY

As one of the most widely used enabling technologies, barcode scanners could be embedded into the suit to collect information from crew members, supplies and locations. This would allow the firefighter to query and report information about his immediate situation without returning to a central control point or being required to manually enter detailed data. By using barcodes to identify doors, equipment and spaces, further mapping of these details to an equipment data base would yield information on routing and location and could be made available instantly. Display of this information relative to the firefighter's current position could be fed back through a mask displayed cursor or pointer rather than the map referenced data now stored back in the lockers. Barcodes could also account for expendables and be used to call up replacement items to the scene of damage.

D. HEAD CONTACT MICROPHONES

Head Contact Microphone (HCM) technology has recently completed the development phase and is expected to move into production in 1999. (Figure 13) Coastal Systems Command of the Naval Surface Warfare Center (NSWC) in Panama City Florida, discovered and developed the prototype to allow Navy Divers to communicate verbally underwater. This same technology has been experimentally incorporated into firefighters helmets in the Pittsburgh Fire Department with great success.[9]

With HCM and speaker sets, firefighters are able to communicate in high noise environments while wearing a facial mask, achieving better clarity than any system previously used.

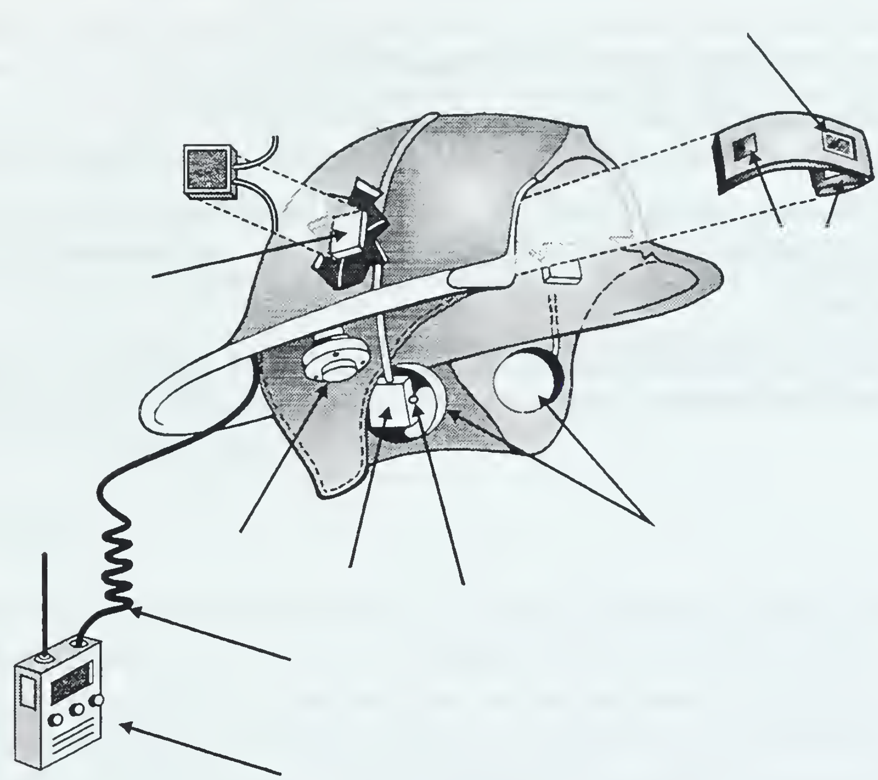

Figure 13. Head Contact Mike And Earphone Assembly.

The breakthrough in this technology lies in the application of vibration sensitive conductive material that is not adversely effected by moisture, heat or a high noise environment. It works through direct contact with the body and is most effective when directly in contact with the scalp area. It picks up the sound vibrations from the head, which result from speech and converts this vibration into a small electrical current that is amplified and processed for transmission to the receiving party. This process eliminates the conventional microphone design problem of inaudiability of various voice characteristics from the OBA mask. Listeners in the vicinity have difficulty due to muffling and distortion caused by the large mask and diaphragm assembly that is necessary with the apparatus.

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V. SURVEY METHODOLOGY

Internet surveys carry a built in resistance to achieving 100 percent coverage of the target population. The methodology used to collect responses will only reach prospective respondents who use the Internet, have access to the WWW, have an active email account and wish to participate. Armed with the knowledge that some of the ships will be at sea and away from WWW access, added to the fact that many users find computers too difficult or time consuming to use, I have attempted to answer questions about all users by collecting responses from a subset of the overall users who could have participated in the survey. This method of surveying is known as sampling, because only a sample of all possible respondents is selected.[1]

A. SAMPLING

Of the two types of sampling, random and non-probabilistic, random sampling is the more desirable form in that it does not discriminate about who should respond to the survey. Random sampling uses a selection process which fortuitously identifies elements from the overall population for inclusion. Thus, each element has the same likelihood of being selected as part of the sample. In non-probabilistic sampling the elements are not selected in random process. By this method, it is frequently true that certain categories of the overall population are not included in the sample as they are not equally likely to be selected.

As an example, the surveyor might only allow respondents to reply to the survey on odd days while he is on duty. It is likely that potential respondents who are not able to answer the survey during even duty days are part of watch sections containing a greater percentage of differently experienced respondents. This is a non-probabilistic survey and shows a systematic bias from the sampling methodology. It is however, quite plausible that the even-day watch sections are not different from the odd ones. This could only be accurately verified by sampling both odd-day and even-day groups.

B. SELF-SELECTION

There is no known accurate listing of the email addresses for all damage control personnel using the Internet throughout the Carrier fleet. This makes it impossible to

identify and contact the overall population. Contacting only those addresses that are available simplifies the problem at the expense of the true reflection of the population. This is not uncommon in Web based surveys due to the dynamic nature of users and accessibility. The concern remains on how to convince known web users to participate. Self-selection happens if prospective respondents within the sample are allowed to chose non-participation. If a group of members from the sample decides against participation, it diminishes the likelihood that the findings will represent the overall population. As a result, confidence in the survey suffers because the group choosing against participation could be different in some respect from actual participants. Self-selection nonetheless, occurs in almost every real survey. If a survey is sent to a ship and the first person who reads it discards it out of fear of a computer virus or because they think ship's schedule is too busy for surveys, self-selection has resulted. Conversely, if in a personally administered survey, specific candidates refuse to respond, self-selection happens once again.

C. THIS SURVEY METHODOLOGY

This survey was completed exclusively over the Internet. The only access to questions was by bringing up the survey posted at my Internet address. No other surveys of this type are known to be available at this time. Results of the survey will be provided to the Naval Sea Systems Command (PMS 378) via this thesis. They will also be provided to any of the respondents who wish to have a copy of the data and findings. Since all potential respondents could not be identified and contacted, the survey uses non-probabilistic sampling. Respondents are invited to participate by the following E-Mail (Figure 14) message:

"Greetings,
I am a student at the Naval Postgraduate School and am studying the potential for new technology to extensively revise our Damage Control systems. My last tour was in Engineering Dept. of CVN 74 so I understand how busy you are and will not waste your time.

The following hyper link is a point and click survey and takes approximately 3 to 5 minutes to complete:

http://members.aol.com/litekiepr/cvxsurvey.htm

For a text only version of the survey (smaller download) this link will do the same thing.

http://members.aol.com/litekiepr/conniesurvey.htm

I would like to use this survey to collect inputs of personnel from every level of the D/C chain of command to determine what are the concerns about innovation of DC technology.

I intend to collate this information into tables and to assess the data to determine trends between different carriers, positions and pay grades.

This data is not intended for release beyond the thesis derived from this study. Your assistance in completing this survey and forwarding this Email to your fellow DC warriors, particularly locker leaders and senior DC division personnel is appreciated. Thank You Again!

LT. Frank Steinbach
Naval Postgraduate School
(831)643-9414
frsteinb@nps.navy.mil
a.k.a. litekiepr@aol.com"

Figure 14. CVX Survey Invitation.

Additionally, no limitation on the number of responses per user is made making potential dilution of the results possible. However, of the 61 responses, no two responses self identified as originating from the same respondent.

Making the website for response available for one month beginning February 15th 1999 and by adapting the file size to accommodate bandwidth limitations of all twelve carriers has minimized the potential of systematic bias in the results. However, contacting alternate email addresses where possible and reselecting ships where responses were lower than average may have impacted the potential for naturally occurring responses and caused some respondents to be asked by superiors to respond to the survey, affecting the expectation of voluntary participation. Considering web based surveys are a fairly new practice, their effect on the outcome remains less understood than conventional surveys.

For the purpose of our analysis, a sample population that is more computer literate and technologically savvy is more useful in making knowledgeable inferences about the issues addressed in this thesis.

Given the limitations that exist in the data as a result of the methodology, we make the following recommendation to those using the data presented within this report:

- It is recommended the this data be presented with the caveat that it has been collected exclusively over the internet and therefore does not include segments of the population who are not familiar with or choose not to use the internet. This is thought to predispose the results to represent only the views of personnel willing and able to consider the potential of new technology solutions to old damage control problems.
- It is recommended that users interested in collecting the full array of damage control personnel conduct an alternate survey using non-web based methods such as mailings or personal interviews.

Although other sources of information support the results of this survey, it is clear that the Survey's sampling methodology is not perfect.

D. PURPOSE OF THE FLEET USER SURVEY

A snapshot of the Navy's recently commissioned carrier HARRY S. TRUMAN (CVN 75), during a damage control training exercise would be virtually indistinguishable in Damage Control composition, techniques and technology from one of the USS NIMITZ (CVN 68) a year after commissioning back in 1975. Unlike many operations in

the Navy where computers are reducing the work of the sailors for communication, for maintenance planning, for equipment control, and for administrative functions, damage control remains a manpower intensive ship-wide occupation.

Over these past 25 years, many of the senior personnel on carriers have gained substantial experience with Damage Control technology and techniques. Their wealth of knowledge often includes experience from several Carriers. During this same time, many devices have been tested, and subsequently adopted or rejected based on the merits of how each one performed in actual use. Examples of this are the WIFCOM[2] radios which have given way to a new more functional HYDRA[3] radios and TWARSES[4] which consisted of a prototype sensor network which was not adopted for fleet use after small group of ships were outfitted with it.

In surveying both the preferences and the expectations of users, I intend to balance the "hype" of technologies unproven in use out in the fleet with the often-sage insight of those prospective users. They have demonstrated a ready and willing attitude to share in formulating the vision of what technologies are desirable and feasible for fleet use. User input is highly recommended by many expert Information Technologists and Management Specialists who advise us that "real communication requires a dialog among the different roles".[5]

> Despite enormous outward success of personal computers, the daily experience of using computers far too often is still fraught with difficulty, pain and barriers for most people.... The lack of usability of software and the poor design of programs are the secret shame of the industry.
>
> Michael Kapor[6]

E. TARGET POPULATION OF THE SURVEY

The Damage Control Assistant (DCA) aboard USS JOHN C. STENNIS (CVN 74) as aboard any other Aircraft Carrier is responsible to train and equip fourteen hundred of the ship's personnel to damage control on a regular basis.[7] Leading these damage control warriors is the DCA's core group of approximately 30 personnel including Repair Locker Leaders and Senior Damage Controlmen who will lead and direct the rest of the crew when the real fire or flooding starts. It is this group of personnel who have been targeted in the survey of potential locker technology included in this thesis.

F. SURVEY COMPOSITION

The survey was made up of two parts. The first seven questions were designed to evaluate wireless communications, video teletraining and decision support systems and flat/touch screen display panels. The second group of 8 characteristics/qualities was graded on a scale of mission importance for new damage control equipment. Respondents were also asked to rate the value of current damage control training and manpower use.

G. SURVEY IMPLEMENTATION

The survey was published on the Internet on a commercial server for maximum availability to all potential respondents. Every Chief Engineer, Damage Control Assistant and Fire Marshall in the Aircraft Carrier Fleet was invited by email to take the survey. Responses were obtained from nearly every ship (Figure 15) with the greatest response from the USS CARL VINSON.

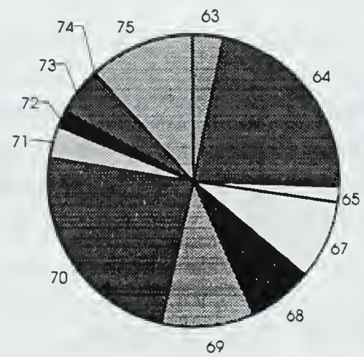

Figure 15. One conventional and one nuclear carrier dominate responses

H. WHAT PERCENTAGE OF THE TARGET AUDIENCE RESPONDED

Comparing by job onboard, 10 out of 12 Damage Control Assistants responded as well as 5 of the 12 Chief Engineers who also serve as Damage Control Officers.

Additionally, 25 of 120 Repair Locker Leaders and 5 Scene Leaders out of 120 responded representing 20 and 4 percent of those currently in the fleet respectively. This represents a significant portion of the overall population.

I. WHAT QUALIFIES THIS TARGET AUDIENCE TO ANSWER THE SURVEY

Damage Control Assistants normally have a pivotal role on carriers as custodian of the damage control technology and the senior user of that technology during a damage control event.

All other respondents are primarily in a custodial or technology user role exclusively. Locker Leaders, Scene Leaders and Fire Marshals each have a user role which enables them to comment from direct experience on the performance of the current performance of installed equipment as well as occasional trial usage of new prototype damage control devices.

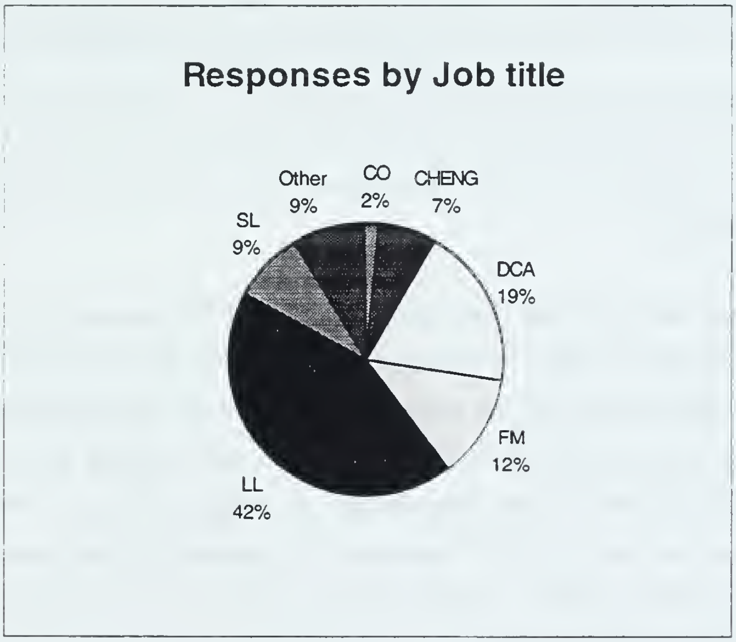

Figure 16. Locker Leaders and DCA's who are most directly involved with the proposed technologies are the best represented in the survey as well.

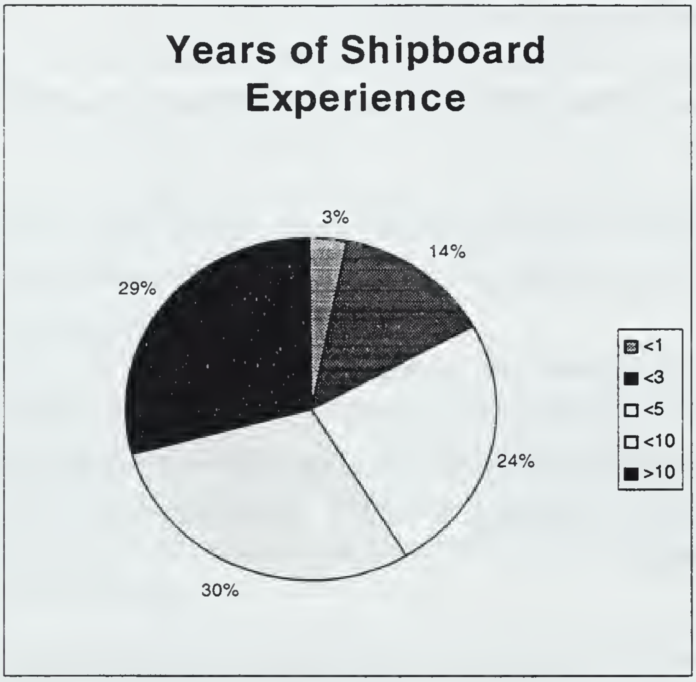

Figure 17 More than half of respondents have more than 5 years Damage Control Experience

J. EXPERIENCE

All respondents indicated they have some level of expertise over half of which have indicated more than 5 years in damage control. This indicates that damage control system familiarity should provide the insight to represent the user perspective accurately. It should be noted however that the survey contains a self filtering aspect of availability only to users with access to and knowledge of computer use as demonstrated by completion of the online survey. Personnel in leadership positions generally use computers in their daily routines. Many ship's requirement for computer literacy of all supervisors may mitigate this concern.

K. TECHNICAL INFORMATION

1. Descriptive Statistics

All analyses were conducted using Excel 97 on Windows95.

2. Execution

The Surveys were executed on a web browser based HTML page. Two versions of the page were made available one with and another without graphics to accommodate low bandwidth availability on several of the ships responding. Web pages were generated using AOLPRESS, a WYSIWYG Web page generator. For more information about how the AOLPRESS, see America Online's provider gateway at http://www.aol.com

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[1] Smith, C. B. "Casting the Net: Surveying an Internet Population", NPS Dissertation, Sept 1997, [http://www.ascusc.org/jcmc/vol3/issue1/smith.html], 01 March 1999.
[2] Rednor, Stuart, "Damage Control Wirefree Communications Opeval Analysis And Lessons Learned", Naval Sea Systems Command., [http://www.navsea.navy.mil/navsea-te/dcwifcom.htm], 16 March 1998
[3] "French Navy selects Ericsson for shipboard communications" [http://www.ericsson.com/US/prs/openmic/ot_w98d.html], 21 March 1999
[4] US Naval Surface Warfare Center, Port Hueneme, "TWARSES installed on USS GARY (FFG 51)" 1994
[5] Jick, T.D. *Managing Change, Cases and Concepts*, McGraw Hill, 1993, New York p. 200
[6] Winograd, T. *Bringing Design to Software*, Addison Wesley, 1996, New York, p. xiii
[7] telephone Conversation Between LCDR K. Yang, DCA of USS JOHN C STENNIS (CVN 47) and the author on 29 Feb 99.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The purpose of this thesis was to develop an evolutionary model with which to evaluate the approaching onslaught of technology opportunities for CVX. Included in the model are a combination of guiding requirements synthesized from doctrine from NAVSEA and The Office of SECDEF and expertise from the Fleet. The model combines the aspects of manpower needs reduction, integration with the ship's technological infrastructure, maturity of the new technology, perceived reliability and preference of fleet experts with respect to specific technology areas, and the inherent capacity of the technology for backfitting to earlier carriers. A time-sequenced and resource-focused approach to the selection process is required. Obtaining community support at it's foundation including surveys such as the one included in this thesis, interviews with fleet users and recruiting of experienced technology users to build a vision of the future systems is essential. Above and after this foundational layer begins is the design layer which requires iterative enhancement of Software Process Improvement and continued hardware evolution through use of best of breed technologies. Above and after this design layer is the implementation layer in which software applications and rapidly developed prototypes of new equipment can be placed with the reduced risk of changes to requirements and incompatibility of the players with process improvement cycles.

Based on the high regard for Video Tele-training, Flat Screen Displays and Decision Support Systems from the fleet experts, these choices warrant close study and when feasible, investment. Selection of a prototype should be based on the aspects of reliability, ruggedness and proven performance over portability and redundancy from an fleet perspective. To ensure that reliability and performance are optimized, the path to the selection and acquisition of these prototypes should consider the value of Software Process Improvement (SPI) and lessons learned from Smart Ship. These lessons include the need to develop a matching support organization for the needs of enhanced technology users and their unconventional systems. Additionally, carriers with network and software intensive systems will require organic expertise to keep the systems reliable and effective.

As only a portion of the overall technological infrastructure of CVX, damage control will naturally be subservient to the collective needs of all of the carrier's functions. Examples of these aspects are in the reassignment of manpower, the use of the radio frequency spectrum, and the tasking of ship wide networking resources during combat.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

1. Establish new technology control group

The purpose of the group would be to collect and perform documented consideration of initiatives taken by surface warfare and subsurface technology developers such as smart ship, DD-21, SC-21 LPD-17 for innovations which merit consideration for addition to the technologies which will be undertaken in CVN-77, CVX and for fleet backfit. Scope of the technologies would include all engineering aspects including those of substantial information technology interest. Representatives on this group should include members from all aspects of carrier warfare including damage control, navigation, communications, etc. Areas identified for consideration could be passed to Naval Research Labs, Naval Postgraduate School or private contractor for further analysis.

2. Trials of three

Of the four technology areas discussed in this thesis warrant further research and are recommended for eventual prototyping. These include:

a. Flat screen display technology

Could interface with carrier local area networks to develop a baseline for application software which emulates existing DC plotting boards and sound powered phone circuits. The second phase of this analysis (after a prototype is developed) would involve a pairwise comparison of existing locker communications with this new system under similar simulated conditions.

b. A commercially available Decision Support Tool

This could be introduced and evaluated by a designated ship which is at full readiness levels for damage control prior to introduction of the tool. An analysis of the tool would include use by several operators and survey analysis of the merits of the tool for incorporation into a request for proposal to commercial providers if they are found to be beneficial.

c. Further analysis of the video teletraining model

VTT installation is being completed on board CVN-75 as of the completion of this thesis. Comparisons with conventional training methods and incorporation of other incremental technology methods including web based test taking could be evaluated for wide scale inclusion of the technology in the other eleven active carriers and future ships.

C. SUGGESTED FURTHER STUDIES

This exploratory study has only begun to uncover the growing body of knowledge on damage control technology. Individual feasibility studies in each of the disciplines described in this thesis are necessary and anticipated. Sponsorship of these evaluations by academic and engineering levels of the Navy will nurture an additional source of expertise for the designers and implementers of CVX. This is part of building the foundational element of community support advocated in Chapter II.

Secondly, an independent analysis of how to most effectively achieve the full value of process improvement both within the Navy and externally from private industrial partners is warranted. This should be done expeditiously to take advantage of the existing long lead time necessary for developing these process initiatives. Additionally, the ability to reliably track the coordination of these efforts must reside within the Navy to minimize software development milestone risks.

Any evolutionary model must include the capability to assess new and innovative applications for training, communications and decision support which can be accommodated within the Carrier Integrated Digital Environment (CIDE) or other hierarchical standard. This thesis provides a model based on a balance of documented requirements by the primary stakeholders in the future of carrier damage control.

Additional factors which have not been entertained by this model include cost, balance with other ship's requirements and other aspects of decision making which bear less on the evolutionary concerns of damage control.

APPENDIX A: USERS SURVEY

CV(X) D/C Technology Survey
This survey is designed collect your view of what can be done to improve the Damage Control System onboard our Aircraft Carriers. Please take a moment to circle your choices in the following questions and pass your answers to the DCA selecting the submit button below.
PLEASE PASS THIS QUESTIONNAIRE ON TO FELLOW D/C PERSONNEL.

Select Your Most Senior D/C Position
XO Cheng DCA Fire Marshal Locker Leader Scene Leader Team Leader Nozzle man Other
****

SELECT YOUR RANK:
- ( ) E1 ( ) E2 ( ) E3 ( ) E4 ( ) E5 ( ) E6 ( ) E7 ( ) E8 ( ) E9
- ( ) W1 ( ) W2 ( ) W3 ( ) W4 ( ) W5 ( ) O1 ( ) O2 ( ) O3 ( ) O4 ( ) O5 ( ) O6

****

1. How many years of Shipboard Experience do you have?

- (•) Less then one year
- ( ) 1 to 3 years
- ( ) 3 to 5 years
- ( ) 5 to 10 years
- ( ) More than ten years

****

2. D/C equipment must be redesigned using new technology from the "Internet age."
(Please indicate the extent to which you agree or disagree with the statement.)

- ( ) Strongly Agree
- ( ) Agree
- (•) No Opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( ) Don't Know

****

3. I would trust the use of Computer Decision aids to help D/C Leaders make D/C ***TRAINING*** decisions

- ( ) Strongly Agree
- ( ) Agree
- (•) No opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( ) Don't know

****

4. I would trust Computer Decision aids to help D/C Leaders make ***REAL TIME CRISIS*** D/C decisions

- ( ) Strongly Agree
- ( ) Agree
- (•) No Opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( ) Don't know

****

5. Flat, touch-screen panels would be a great improvement on D/C plates and pubs in repair lockers. They will also provide equipment status and personnel accounting in ***future*** D/C lockers.

- ( ) Strongly Agree
- ( ) Agree
- (•) No opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( ) Don't know

****

6. Wireless computers would work well in place of existing "JZ" phone circuits.

- ( ) Strongly Agree
- ( ) Agree
- (•) No opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( ) Don't know

****

7. Individual computer video-teletraining would improve the D/C training of all hands.

- ( ) Strongly Agree
- ( ) Agree
- (•) No Opinion
- ( ) Disagree
- ( ) Strongly Disagree
- ( )

Don't Know

****

8. Rate the following properties of D/C equipment as

A . Mission essential B. Very important C. Important D. Useful but not essential E. Unimportant

Portability	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Weight:	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Ruggedness	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Reliability	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Lots of Spares	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
User Friendly	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Standard to the fleet	( ) A.	( ) B.	( ) C.	( ) D.	(•) E.
Proven in action	( ) A.	( ) B.	( ) C.	(•) D.	( ) E.

****

9. Current damage control training evolutions on aircraft carriers are the best way to maximize learning and the most effective use of manpower

- Strongly Agree
- Agree
- No Opinion
- Disagree
- Strongly Disagree
- Don't Know

****

Name ____________________

Email: ____________________

ANY CONCEPTS, COMPLAINTS or COMMENTS TO ADD?

____

____

____

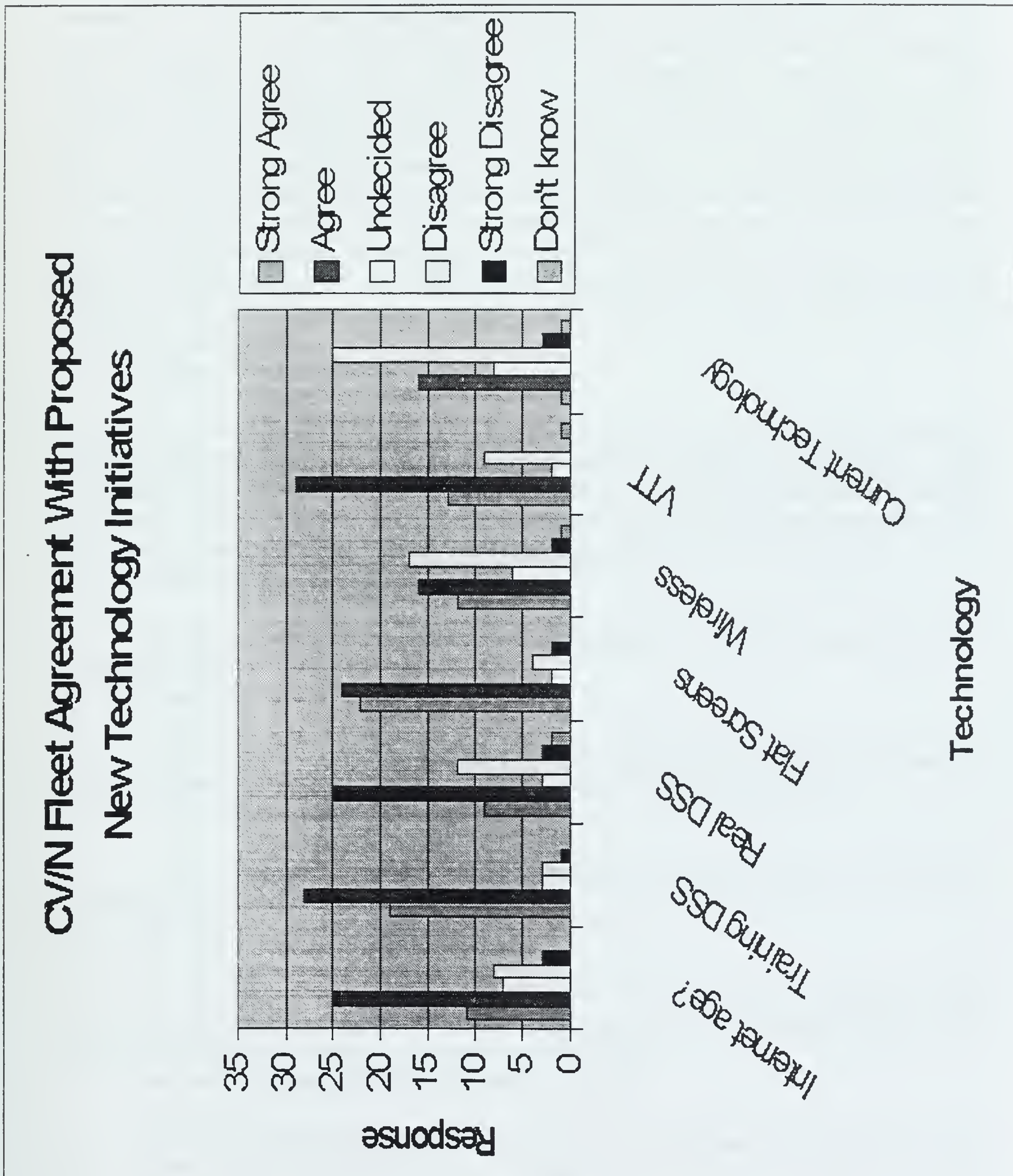
____

____

Submit Reset

Thanks for you time and your valuable input! This study is being conducted by a student at the Naval Postgraduate school for the CVX Program Office. Information or implied opinions shown herein are not intended to reflect those of the United States Navy or US Government.
The site is on a commercial server so that you can access it from anywhere.
Contact me, frsteinb@nps.navy.mil for info on this research.

APPENDIX B: FLEET TECHNOLOGY PREFERENCES



APPENDIX C: SURVEY COMMENTS

Before we invest a lot of scarce capital in fancy electronic systems, we need to fix some of the basic design problems that plague dc efforts. First among many is to use 70/30 CUNI (or titanium) piping in all saltwater systems. We continue to use STEEL or Galvanized Steel in vital CMWD/AFFF/sprinkler/flooding systems! (Not to mention the continued use of steel in: firemain, flushing, drains and many other corrosive systems.) The next that comes to mind is the main space fire doctrine. If we are serious about putting out large main space fires, we need to design our ships with unit lockers at the bottom of escape trunks with installed AFFF hose reels. The two hose attack of a main space fire should come from the 7th deck not the 2nd! Next, we need to rapidly switch to the Scott air pack and get rid of the antiquated OBA. These three problems alone would cost millions to implement on existing carriers. I have more....

William Doner, Cheng, CVN-70

Equipment is only as good as the personnel that use it. 90% of shipboard Damage Control in a casualty situation is common sense and reactions. The only thing that I liked about the above conditions, were the touch screen panels. This would be extremely useful for automatic boundaries and activation and securing of fixed systems. Other than that, everything is fine the way it is.

Kevin Ginter, SL, CVN-70

#7 Video Tele training has limited applicability. Hands on training can not be totally replaced.

Greg Smith,DCA, CV-64

Need to look at the so-called training commands and the way they do business. Need technology to reach the fleet in a more timely manner.

Werner,D.A, CWO2, CV-64

A live instructor with "actual" equipment cannot and must not be substituted by a 2 dimensional medium.

Owings, Donald T, FIRE MARSHAL, CV-68

I'm not fully aware of the capabilities of the system(s) mentioned in this survey, however any change over the existing means of communications and plotting standards would be a marked improvement.

Marvin Campbell, FIRE MARSHAL, CVN-69

There are many new systems or training aids that seem to take forever to be installed across all the carriers. SCBAs are only on Truman as a full

replacement to OBAs. Maybe one carrier has the new Chem/Bio suit and all the other ships have the old CPO suits with expired shelf lives. New style EEBDs have been sent to JFK and to 2 other carriers, but we still have no training EEBD units and no training video which was slated to arrive in Sept 98. The ops tempo both inport and underway and the ever necessary major maintenance requirements inport, make it tough to find time to shipcheck new systems, provide training for operators and then to begin to utilize the new system. Communications is always a trouble area for DC evolutions - anything to improve on that (WIFCOM - which by the way JFK does not have - or some type of real time computer sharing of information - sort of like NTDS) would greatly benefit over coordination.

Requested anonymous

I don't think that the Fire Fighting and Team training for Carriers that I've been exposed to, is adequate or structured, as it needs to be. The complacency I have found since reporting to Carrier Duty really bothers me. So I have to say that onboard training and monitoring is not enough, or effective. I can only guess that the ORSE Team that grades Carrier evolutions, That graded our last ORSE, must never have been exposed to really well trained Emergency Fire Parties. I say this because they said that this Flying Squad was the best they had ever seen. I've been on several ships prior to this and have never seen such complacency as I have seen here. I'm astounded at the evaluation. We need more outside training and monitoring to ensure objectivity and high quality standardized training to build from.

Alan Lomax, Scene Leader., CVN-70

MOB reporting needs to be tailored to specific carrier lockers and needs to be able to be tailored by DCTT. For example, the requirements for shoring and casualty power rigging My Locker, 7F, located on the O3 level forward. I have only 1 actual emerg casualty power requirement (Cats 1 & 2) which is a Q-1. Also, all wood shoring has been removed from my locker to below decks lockers which is a M-1. Good luck on your Masters.

Sam Scafe, Locker Leader, CVN-70

The main things I worry about computerized systems are the need for electrical power. Also computers lack emotion which could be good and bad. If these areas were guaranteed to be problem free, computerized systems would be an awesome way to go.

Washington, Aaron, RDIVO, CV-63

I'm excited about the effort that is being given to the technological advancements of Damage Control systems. I spent some time with a group of CVX planners prior to our last deployment. I have to admit though, I am very concerned about our young sailors and their ability to physically combat damage

when the computer has identified it and suggested how to correct it. I'm not sure if we can build ships that will not have to be manned or cost effective enough so that we can simply abandon ship if it gets really bad. Keep up the great work and best of luck.

DCC(SW) James R Pace, FIRE MARSHAL, CVN-69

We should not rely too much on computer and "high tech" equipment to save our lives. They are nice but easily destroyed. I stand watches on the bridge and I have seen how easy "high tech" equip. Like the Flat panel displays can be corrupted and destroyed. Let's concentrate on hands training "real life" training with our most reliable "high tech" equipment, to wit: Our Shipmates. Every day they decide whether we live or die.

Eric McDonald, LOCKER LEADER, CVN-70

Training should be a combination of specific skills training followed by a drill that exercises the skill training.

Locker Leader, CV-64

DC training is very time intensive with existing equipment and increased technology would increase required training. This would unnecessarily increase training required in training personnel in a high turnover collateral job.

LTjg Lahti, ADCA, CV-64

Having gone through Damage Control from my earliest days as a Rep Locker leader to being Engineer of CVN-65 and CO of DD-972, my views may be somewhat unexpected. My current billet has afforded me an opportunity to see how we train, and unfortunately how we must fight fire. We no longer have the "real" fire fighting trainers with a lot of smoke, heat, and flame. That is THE BEST WAY to "learn not to burn". The so-called "War Wagons" available in each homeport are great for everything but fire fighting. We need to get better simulations for fires, we need to be able to use smoke generators where ever fire could start, including the propulsion plants of CVNs. The innovative use of civilian DC training equipment (multiple flashing lights, sound, and large capacity smoke generators, coupled with charged hoses on sponsons for both fire fighting and pipe patching has done wonders for the DC teams on ENTERPRISE, but it is not enough. My main concern with computer aids and touch screens in the lockers is the

Capt Nusselrode, Cheng, CVN-65

There are many areas that could be improved on with DC equipment-I think that a SCOT-pack replacement to the OBA is one, but the absolutely biggest difficulty I see in GQ DC is communications. I would give up half of my locker for WIFCOM or its equivalent. Add to this a difficulty in realistic training scenarios to practice comms and it makes my job much, much harder. I find that

the prolific use of messengers to be a semi-effective means of maintaining comms, but it is horribly inefficient. Many of the items mentioned in this survey could be of great benefit-if they work, are user friendly and work!

LT Kevin D. Johnson, Locker Leader, CVN-70

With reference to question #6, the wireless computers would be nice, but I feel it important that the standard JZ circuits still be available for contingency purposes.

RANDY E. RAKENTINE, Scene Leader, CVN-70

Evacuation routes have been the bane of our D/C scenarios. Poor communications to and from the lockers and DC Central Medical lead to "critical" patients expiring (simulated, of course) while waiting for safe routes. The long time span also sends the stretcher-bearers into areas that are no longer "safe". Good luck, reliability of comms would be the best answer, the backstop will always be a messenger.

LT Kelly Gann, Medical, CVN-70

There are many areas that could be improved on with DC equipment-I think that a SCOT-pack replacement to the OBA is one, but the absolutely biggest difficulty I see in GQ DC is communications. I would give up half of my locker for WIFCOM or its equivalent. Add to this a difficulty in realistic training scenarios to practice comms and it makes my job much, much harder. I find that the prolific use of messengers to be a semi-effective means of maintaining comms, but it is horribly inefficient. Many of the items mentioned in this survey could be of great benefit-if they work, are user friendly and work!

LT Kevin D. Johnson, Locker Leader, CVN-70

APPENDIX D:VPX SIMPLE DECISION SUPPORT SYSTEM RULES BASE

```
RUNTIME;
ACTIONS
    WOPEN 1,2,6,10,60,0
    MOUSEOff
    ACTIVE 1
    DISPLAY "
           This expert system advises you on which
           Fire fighting agents to use to fight
           different types of shipboard fires.

           Press any key to begin the consultation.~"
     CLS
     FIND Agent
     WOPEN 2,13,13,7,48,0
     WOPEN 3,14,14,5,46,0
     ACTIVE 3
     LOCATE 2,2
     DISPLAY "
The safest and most effective fire fighting
agent for the job is {#Agent}.

(Press any key to conclude the consultation)~"

!     WCLOSE 3
!     WCLOSE 2
!     WCLOSE 1
;

RULE 1
IF      Smoke_Color = White OR
        Smoke_Color = Black AND
        Smoke_Color <> Blue AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = No
THEN
        Agent = AFFF
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 1A
IF      Smoke_Color = White OR
        Smoke_Color = Black AND
        Smoke_Color <> Blue AND
        Ventilation = Off AND
        Power = No
THEN
        Agent = CO2_or_HALON
        BECAUSE "To choose a safe and effective fire fighting
```

```
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 2
IF      Smoke_Color = White OR
        Smoke_Color = Black AND
        Smoke_Color <> Blue AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = Yes
THEN
        Agent = AFFF_or_Water
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 2A
IF      Smoke_Color = White OR
        Smoke_Color = Black AND
        Smoke_Color <> Blue AND
        Ventilation = Off AND
        Power = Yes
THEN
        Agent = AFFF_or_Water
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 3
IF      Smoke_Color = Blue AND
        Smoke_Color <> White OR
        Smoke_Color <> Black AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = No
THEN
        Agent = CO2
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 3A
IF      Smoke_Color = Blue AND
        Smoke_Color <> White OR
        Smoke_Color <> Black AND
        Ventilation = Off AND
        Power = No
THEN
```

```
        Agent = PKP
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 4
IF      Smoke_Color = Blue AND
        Smoke_Color <> White OR
        Smoke_Color <> Black AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = Yes
THEN
        Agent = CO2_or_Water
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 4A
IF      Smoke_Color = Blue AND
        Smoke_Color <> White OR
        Smoke_Color <> Black AND
        Ventilation = Off AND
        Power = Yes
THEN
        Agent = CO2_or_AFFF
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 5
IF      Smoke_Color = Black AND
        Smoke_Color <> White AND
        Smoke_Color <> Blue AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = No
THEN
        Agent = AFFF_or_PKP
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 5A
IF      Smoke_Color = Black AND
        Smoke_Color <> White AND
        Smoke_Color <> Blue AND
        Ventilation = Off AND
```

```
        Power = No
THEN
        Agent = PKP
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 6
IF      Smoke_Color = Black AND
        Smoke_Color <> White AND
        Smoke_Color <> Blue AND
        Ventilation = On OR
        Ventilation = Unknown AND
        Power = Yes
THEN
        Agent = AFFF_or_Water
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

RULE 6A
IF      Smoke_Color = Black AND
        Smoke_Color <> White AND
        Smoke_Color <> Blue AND
        Ventilation = Off AND
        Power = Yes
THEN
        Agent = HALON_or_CO2
        BECAUSE "To choose a safe and effective fire fighting
Agent for a particular type of fire, it's necessary to know
what the ignition source is made of, whether the power is secured
in the area where the fire fighting will take place, and what color
the smoke is.";

ASK Smoke_Color : "Which of the following smoke colors is
present in the area of the fire?";

CHOICES Smoke_Color : White, Black, Blue;

ASK Power : "Is the electrical power Secured in the vicinity
of the fire fighting area?";

CHOICES Power : Yes, No;

PLURAL : Smoke_Color;

ASK Ventilation : "Which of the following  best describes the
ventilation in the area where the fire will
be fought?";

CHOICES Ventilation:
On, Unknown, Off;
```

APPENDIX E: VPX SCREEN SHOTS

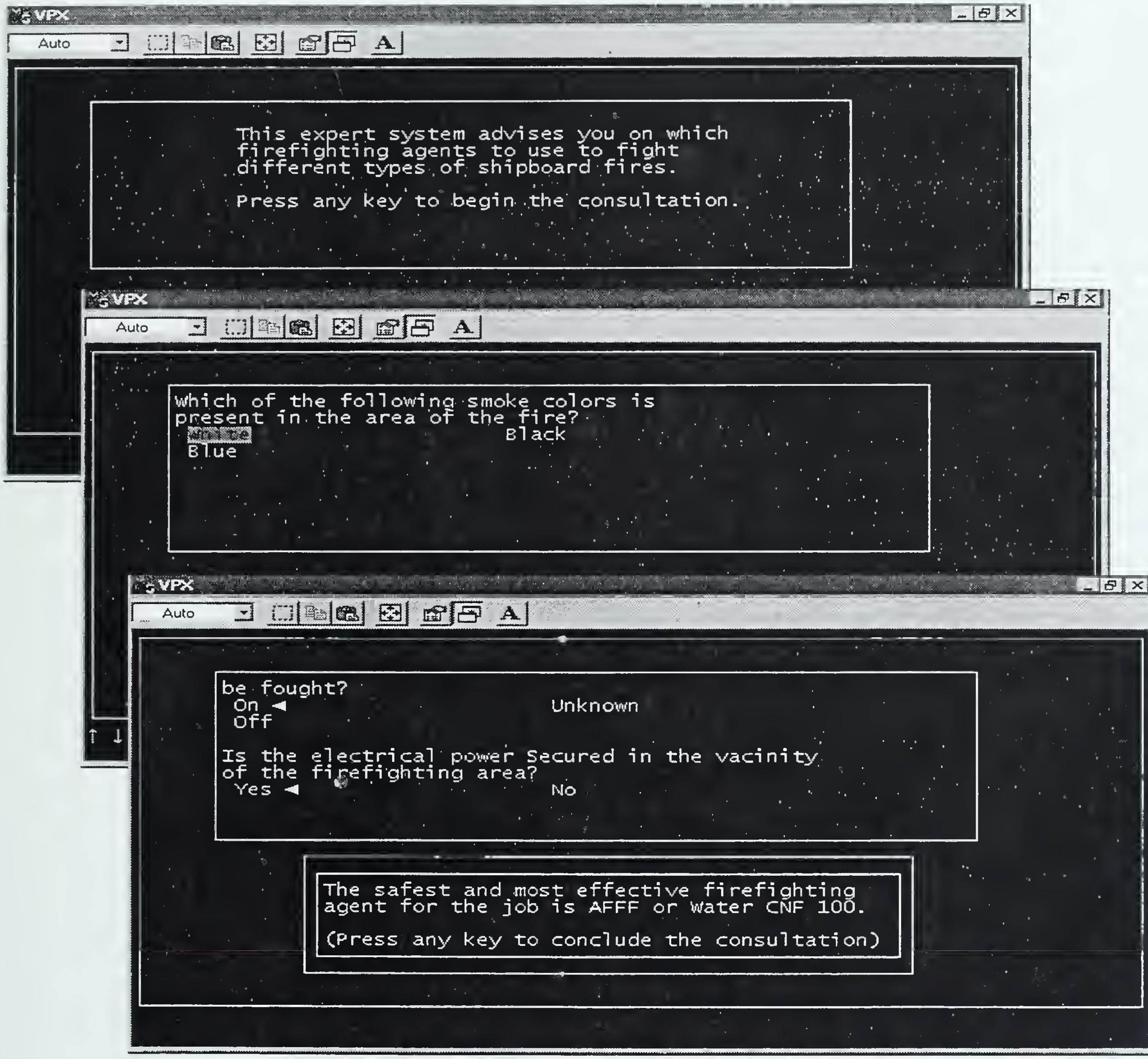


Figure 18. Views of the VP Expert Decision Support Interface demonstrating agent selection for fire fighting based on expert knowledge based input to the inference engine.

GLOSSARY

AAW	Anti Air Warfare
AMLCD	Active Matrix Liquid Crystal Display's
ASUW	Anti Surface Warfare
ASW	Anti Submarine Warfare
BUPERS	Bureau of Naval Personnel
C2	Command and Control
CASREPs	Casualty Reports
CBA	Cost Benefit Analysis
CCS	Central Control Station
CESN	CNET Electronic Schoolhouse Network
CG	Cruiser, Guided Missile
Cheng	Chief Engineering Officer
CIC	Combat Information Center
CMM	Capability Maturity Model
CNET	Commander Naval Education and Training
CNO	Chief of Naval Operations
CO	Commanding Officer
COTS	Commercial Off the Shelf
CRUDES	Cruiser/Destroyer ships
CSOSS	Combat Systems Operational Sequence System
CV	Aircraft Carrier, Conventional Fuel Propulsion
CVN	Aircraft Carrier, Nuclear Propulsion
D/C	Damage Control
DARPA	Defense's Advanced Research Projects Agency
DCA	Damage Control Assistant
DCNO	Deputy Chief of Naval Operations
DCS	Damage Control System
DCTT	Damage Control Training Team
DD	Destroyer
DDG	Destroyer, Guided Missile
DOD	Department of Defense
DON	Department of the Navy
DSS	Decision Support System
EOOW	Engineering Officer of the Watch
FF	Frigate
FFG	Frigate, Guided Missile
FPD	Flat Panel Display
FY	Fiscal Year
GAO	General Accounting Office
HDTV	High Definition Television
HYDRA	Hierarchical Yet Dynamically Reprogrammable Architecture
IBS	Integrated Bridge System
ICAS	Integrated Condition Assessment System
IDEAL	Initiating, Diagnosing, Establishing, Acting and Learning
IT	Information Technology

LAN	Local Area Network
MPN	Manpower Personnel Navy Budget
NAVMAC	Navy Manpower Analysis Center
NRAC	Naval Research Advisory Committee
O&M	Operation and Maintenance
OOD	Officer Of the Deck
OSD	Office Of the Secretary Of Defense
POE	Projected Operating Environment
PQS	Personal Qualification Standard
PRD	Prospective rotation Date
RCM	Reliability Centered Maintenance
RDTE	Research, Development, Test and Evaluation
ROC	Required Operational Capabilities
SC 21	Surface Combatant of the 21st Century
SMCS	Standard Monitoring and Control System
SPI	Software Process Improvement
SPICE	Software Process Improvement and Capability dEtermination
SWO	Surface Warfare Officer
TAO	Tactical Action Officer
USDC	United States Display Consortium
VOD	Video On Demand
VTC	VideoTele-conferencing
VTT	VideoTele-training

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